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Atlantic Skipjack Tuna: Influences of Mean Environmental Conditions on Their Vulnerability to Surface Fishing Gear

R. H. EVANS, D. R. McLAIN, and R. A. BAUER

Introduction

Of those tunas which are exploited commercially in the Atlantic, only the skipjack tuna, *Katsuwonus pelamis,* appears presently exploited at a level below that corresponding to maximum sustainable yield (Matsumoto, 1974). As a result, further increases in fishing effort by the international fleet may logically be directed toward this species. Realization of an economic return from such increased effort is complicated by the fact that the skipjack tuna is a fast swimming, wide ranging species (Kearney, 1976) which inhabits much of the tropical and subtropical Atlantic. Its availability by area and time varies greatly and it is only under certain conditions that skipjack tuna are sufficiently concentrated for economic harvest by surface gear (troll, pole and line, and purse seine).

Researchers and fishermen alike have long sought to improve the harvest of skipjack tuna by attempting to identify areas of high concentration. For fishermen this effort has taken the form of increased scouting activity over larger and larger areas. For researchers it includes identifying those areas where skipjack tuna forage is plentiful (Brandhorst, 1958; Blackburn and Laurs, 1972), ascertaining migration patterns of skipjack tuna (Rothschild, 1965; Fink and Bayliff, 1970; Williams, 1972), and defining preferred skipjack tuna habitat or habitat constraints as inferred from physical environmental indicators (Ingham, 1970; Ingham et al., 1977; Barkley et al., 1978; Sharp, 1979).

The approach of using physical environmental indicators to infer habitat limits of skipjack tuna appears preferable to habitat forecasts based on skipjack tuna forage or migration patterns because of the limited data available to assess these factors. In contrast, a comparatively large amount of physical oceanographic data is available for comparison with catch statistics since oceanographic observations are routinely made for other purposes.

Physiological experiments on captive skipjack tuna from the Pacific have been carried out to ascertain habitat preference as functions of several environmental indicators (Dizon, 1977; Dizon et al., 1977, 1978). No attempt has been made to integrate existing environment/habitat relationships and data with Atlantic catch data to define those areas where skipjack tuna should be available to surface gear. This paper attempts to do this and, in doing so, to develop working hypotheses for identifying areas of potential skipjack tuna concentration as an aid to exploiting and managing the resource.

ABSTRACT—Pertinent data and literature are examined to determine the effects of the environment on the spatial distribution of skipjack tuna, Katsuwonus pelamis, *in both the Atlantic and Pacific Oceans. Environment/skipjack distribution relationships derived from this information are applied to long-term annual mean distributions of dissolved oxygen and thermal structure for the Atlantic Ocean between lat. 40°N and 40°S. The depth of skipjack habitat is mapped. Within the defined habitat areas, high vulnerability of skipjack tuna to surface gear is inferred and areally compared with the long-term catch of the FIS (French, Ivory Coast, and Senegalese) fleet to confirm the validity of this approach. This technique is then used to hypothesize areas of vulnerability of skipjack to surface gear outside the range of the FIS fleet effort in the western Atlantic. Finally, the effects of surface winds on fishing operations are discussed and those areas where wind speed may hamper operations are outlined for the Atlantic Ocean between lat. 30°N and 30°S.*

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Environmental Constraints on Habitat

Temperature

Through the years researchers have attempted to use environmental parameters to define the distribution limits of skipjack tuna or to infer skipjack tuna-preferred habitat areas. Data on water temperature and most notably sea surface temperature has received greatest attention. Both Blackburn (1965) and Nakamura (1969) indicated that distribution limits for skipjack tuna can be defined using sea surface temperature. Laevastu and Rosa (1963) indicated worldwide occurrence of skipjack tuna is confined to the 17°-28°C range and that major skipjack tuna fisheries are found in the 19°-23°C range. More recently, Williams (1970) stated that adult eastern tropical Pacific skipjack tuna are most numerous at sea surface temperatures between 20° and 29°C. Miller and Evans[1] found that for 86 successful purse seine sets made on skipjack tuna in the eastern tropical Pacific, sea surface temperatures ranged from less than 20° to 30°C, with a pronounced mode at about 28.4°C (Fig. 1). Barkley et al. (1978) drew upon test data for captive skipjack tuna presented in Neill et al. (1976) and Dizon et al. (1977) to hypothesize that the habitat of Pacific skipjack tuna is confined to water temperatures equal to or greater than 18°C.

Another temperature related parameter which has been used to define skipjack tuna habitat limits is the depth of the isothermal or mixed layer. Green (1967) related the depth of the eastern tropical Pacific mixed layer to tuna purse seining success (Fig. 2A). Blackburn and Williams (1975) indicated that areas of high apparent skipjack tuna abundance

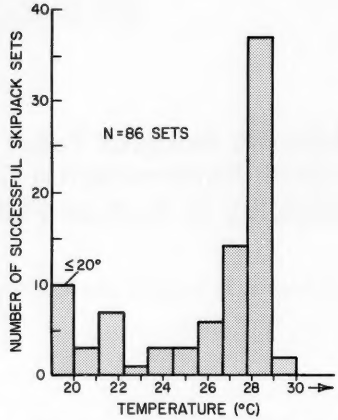

Figure 1.—Distribution of successful eastern tropical Pacific purse seine sets on skipjack tuna as a function of sea surface temperature (from Miller and Evans, footnote 1).

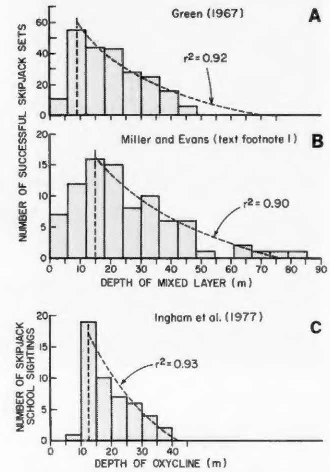

Figure 2.—Distribution of skipjack tuna school sightings and numbers of successful skipjack tuna purse seine sets as functions of the depths of the oxycline and mixed layer, respectively. A log curve has been fitted to the intervalized data to the right of the mode in each case.

in the eastern tropical Pacific are limited to areas where the mixed layer is less than 40 m deep. Miller and Evans (footnote 1) have examined the depth of the mixed layer and find that successful eastern tropical Pacific skipjack tuna sets are limited to mixed-layer depths of less than 85 m. Their findings show a pronounced mode for purse seine set success at 15 m (Fig. 2B) as well as a relation between skipjack tuna purse seine success and thermocline gradient (not shown).

Dissolved Oxygen and Salinity

Dissolved oxygen concentration has also been used to define skipjack tuna habitat. Barkley et al. (1978) have drawn on the work of other researchers to propose 3.5 ml/l as the minimum concentration of dissolved oxygen routinely tolerated by Pacific skipjack tuna. Ingham et al. (1977) found the depth of the 3.5 ml/l oxygen surface in the eastern Atlantic was related to surface skipjack tuna school sightings (Fig. 2C). Dizon (1977) indicated that captive skipjack tuna do not respond to rather drastic changes in salinity, but York (1969) has used salinity with some success in New Zealand as an "indicator" of areas of increased skipjack tuna availability. The increase in availability found by York is probably due to the presence of ocean fronts and/or convergence zones as indicated by variations in the distribution of salinity rather than by direct effects of salinity on the behavior of skipjack tuna.

Forage

Forage of skipjack tuna has been examined relative to skipjack tuna abundance. Dragovich (1970) examined the stomach contents of skipjack tuna caught by pole and line, longline, trolling, and purse seine in the eastern and western tropical Atlantic. Blackburn and Laurs (1972) used data collected during the EASTROPAC (Eastern

[1] Miller, F. R., and R. H. Evans. The ocean environment of the eastern tropical Pacific as related to tuna purse seining. In prep.

Tropical Pacific) experiment to map the distribution of skipjack tuna forage in the eastern tropical Pacific. Blackburn and Williams (1975) found eastern tropical Pacific skipjack tuna distribution correlated with the nighttime concentration of skipjack tuna forage.

Weather

The marine environment can affect the efficiency of the fishing operation and, as a result, skipjack tuna vulnerability. Yuen (1959) indicated that cloudiness is correlated with the ability of fishermen to spot surface or near-surface skipjack tuna schools. Miller and Evans (footnote 1) found purse seine operations severely hampered when wind speed exceeds 8 m/second, with no successful sets made where wind speeds exceed 11 m/second (Fig. 3).

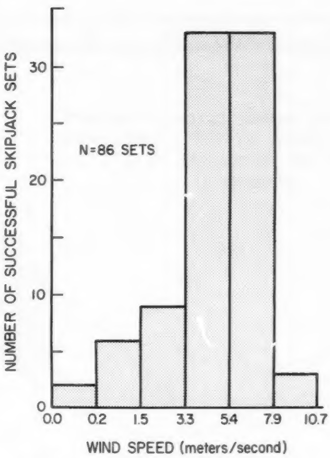

Figure 3.—Distribution of successful eastern tropical Pacific purse seine sets on skipjack tuna as a function of wind speed (from Miller and Evans, footnote 1).

Data Processing and Analysis

An examination of the methods used by previous researchers and the availability of pertinent Atlantic environmental data indicates that the approach taken by Barkley et al. (1978) is well suited to defining skipjack tuna habitat over large areas. Their method, developed from work done on Pacific skipjack tuna, uses the shallower of either the 18°C isotherm or the 3.5 ml/l dissolved oxygen surface as the skipjack tuna habitat lower boundary. Since Ingham et al. (1977) have used the 3.5 ml/l depth with success to define Atlantic skipjack tuna habitat limits, it was felt that this concentration was appropriate. Using only the depth of the 18°C isotherm as per Barkley et al. (1978), presents a problem as water temperature tolerance by skipjack tuna is size specific. They stated that all skipjack tuna have a lower boundary of 18°C but that the upper boundary for 40 cm (1.15 kg) fish is about 29°C while the upper boundary for 70 cm (7.34 kg) fish is about 23°C. Since 40 cm skipjack tuna are the smallest animals consistently taken in western Atlantic commercial catches (Coan, 1976), it was decided to set upper and lower thermal habitat boundaries for this study at 29° and 18°C, respectively. Since the sea surface temperature in this study is almost always less than 29°C (Fig. 4), this means the habitat of skipjack tuna would extend from the sea surface to the depth of either the 18°C isotherm or the 3.5 ml/l surface, whichever is shallower.

Data utilized herein were collected from a number of sources. Sea surface temperature contours were prepared from surface synoptic marine weather data, archived by the Fleet Numerical Oceanography Center (FNOC), Monterey, Calif. To prepare these data for analysis, sea surface temperature values for the period March 1971 to March 1979 were extracted, edited, checked for errors, and averaged by month and 1° square for the Atlantic Ocean between lat. 40°N and 40°S. An annual mean field for the same area was then created by taking the mean of the 12 monthly means for each 1° square. This annual mean sea surface temperature field was then computer smoothed and contoured (Fig. 5).

The depth of the 18°C isotherm was computed from data in two data files: 1) The Bauer-Robinson Numerical Atlas data file[2], File A, and 2) the National Oceanographic Data Center (NODC) station data format two (SD2) file (NODC, 1973), File B. File A for the Atlantic north of lat. 5°S contained water temperature data derived from all available mechanical bathythermograph, expendable bathythermograph, and hydrocasts taken prior to 1976. These data were organized by 1° square averages, by month, for water temperature, tabulated at 30 m intervals from the sea surface to 150 m. Below 150 m, File A contained data summarized at standard hydrocast levels. For each 1° square in File A, the mean depth of the 18°C isotherm was calculated using linear interpolation between the tabulated data points.

For areas south of lat. 5°S, File B, containing unsummarized hydrocast data, was used. For each File B hydrocast, the depth of the 18°C isotherm was computed by linear interpolation between observed levels. These values were then summarized by 1° square and month. The two mean fields derived from Files A and B were then merged and treated as was sea surface temperature to create an annual mean contour plot of the depth of the 18° C isotherm (Fig. 6).

The depth of the 3.5 ml/l dissolved oxygen surface was extracted from File B for the area in the Atlantic Ocean between lat. 40°N and 40°S using linear interpolation methods similar to those used to

[2]Made available by Compass Systems, Inc., San Diego, Calif. Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

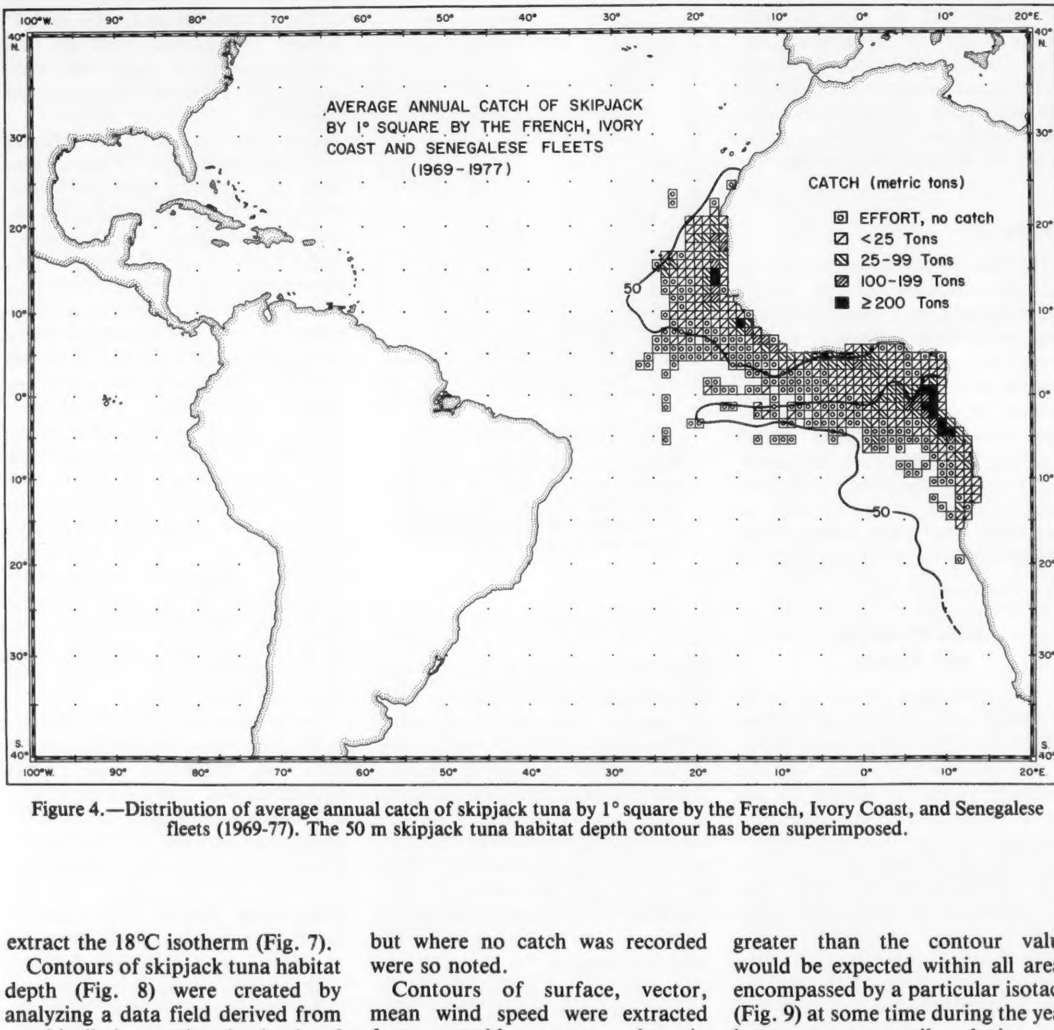

Figure 4.—Distribution of average annual catch of skipjack tuna by 1° square by the French, Ivory Coast, and Senegalese fleets (1969-77). The 50 m skipjack tuna habitat depth contour has been superimposed.

extract the 18°C isotherm (Fig. 7).

Contours of skipjack tuna habitat depth (Fig. 8) were created by analyzing a data field derived from graphically integrating the depths of the 18°C isotherm (Fig. 6) and the 3.5 ml/l dissolved oxygen surface (Fig. 7). Mean total catch in metric tons (t) by 1° square for the French, Ivory Coast, and Senegalese (FIS) fleet were extracted from ICCAT (International Commission for the Conservation of Atlantic Tunas) data bases for 1969 through 1977 (Fig. 4). These data were summed for all years, averaged, and plotted by 1° square. Those areas where fishing effort occurred in any year but where no catch was recorded were so noted.

Contours of surface, vector, mean wind speed were extracted from monthly contour plots in Hastenrath and Lamb (1977). Annual mean wind speed for the area lat. 30°N to 30°S in the Atlantic was obtained from their data by plotting monthly isotachs and then abstracting an envelope which contained all 12 monthly wind speed contours (Fig. 9). The contours presented are therefore not contours of mean wind speed but are annual, areal, composite ranges of the individual vector, mean wind speeds. Vector mean wind speed values equal to or greater than the contour value would be expected within all areas encompassed by a particular isotach (Fig. 9) at some time during the year but not necessarily during all months.

Discussion

Traditionally, surface fisheries for Atlantic skipjack tuna have been largely confined to eastern tropical areas for which representative catch-effort data are available. No such time series of catch-effort data exists for the more localized fishing areas of the western Atlantic and an alternate method of identifying

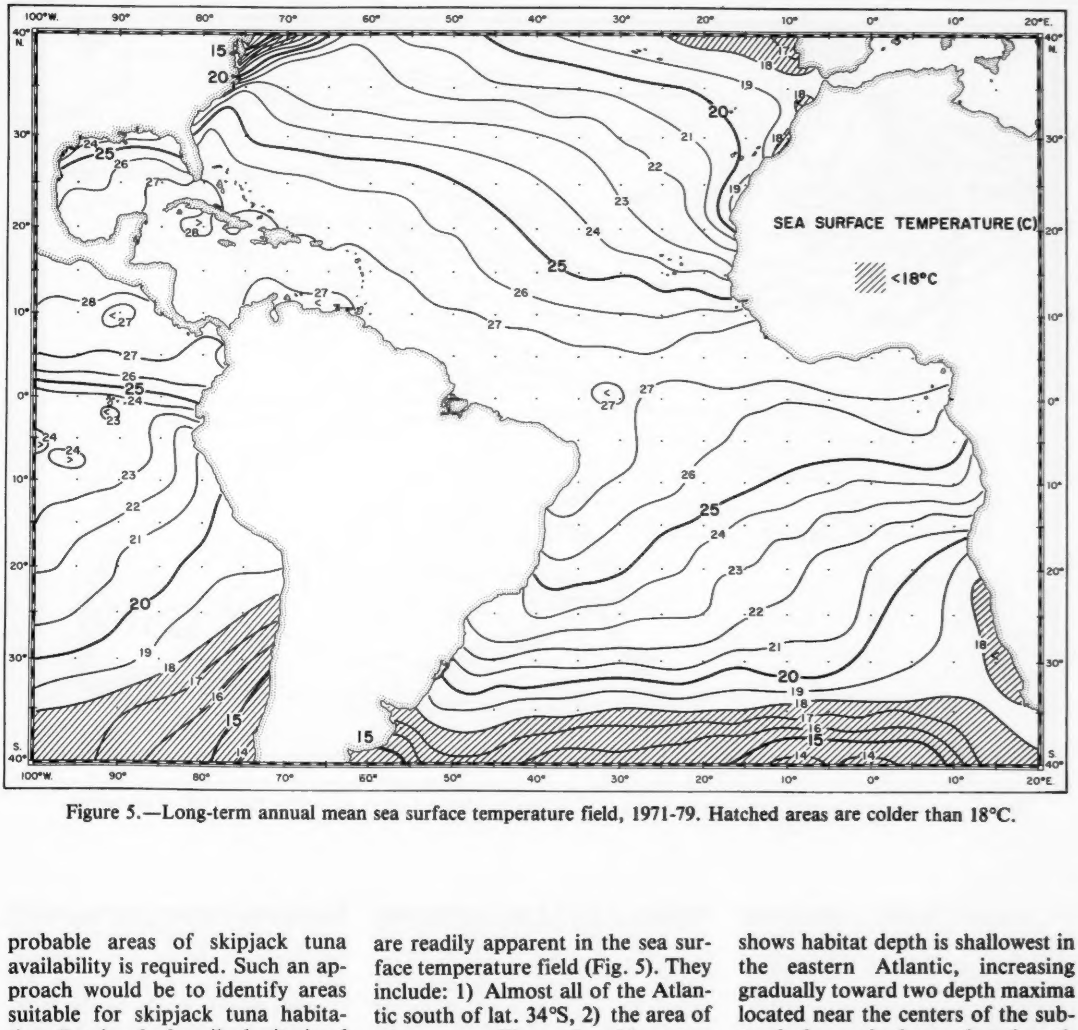

Figure 5.—Long-term annual mean sea surface temperature field, 1971-79. Hatched areas are colder than 18°C.

probable areas of skipjack tuna availability is required. Such an approach would be to identify areas suitable for skipjack tuna habitation. Previously described criteria of Barkley et al. (1978) (those regions confined within the 3.5 ml/l and 18°C surfaces) were used to define areas suitable for skipjack tuna habitation in the Atlantic between lat. 40°N and 40°S.

In using the 18°C isotherm as a lower thermal boundary for skipjack tuna habitat, there are some areas of the Atlantic where the entire water column is colder than this value. Those areas, which are shown to contain no skipjack tuna habitat, are readily apparent in the sea surface temperature field (Fig. 5). They include: 1) Almost all of the Atlantic south of lat. 34°S, 2) the area of strong upwelling of cold waters along the coast of southwest Africa between lat. 20°S and 34°S, 3) two smaller upwelling areas off the northwest coast of Africa, 4) the water northwest of Portugal, and 5) the waters off the east coast of the United States north of the Gulf Stream.

Remaining areas having surface temperatures in excess of 18°C are potential skipjack tuna habitat areas. Examination of habitat depth as defined by 18°C isotherm (Fig. 6) shows habitat depth is shallowest in the eastern Atlantic, increasing gradually toward two depth maxima located near the centers of the subtropical gyres in the north and south Atlantic. These areas of maximum thermal habitat depth are separated by a ridge of shallower depth located between the Equator and lat. 10°N caused by equatorial upwelling. Several of the areas of shallowest thermal habitat off northwest and southwest Africa and the area off the south coast of Brazil are coincident with areas of coastal upwelling.

Depth contours of the 3.5 ml/l dissolved oxygen surface (Fig. 7),

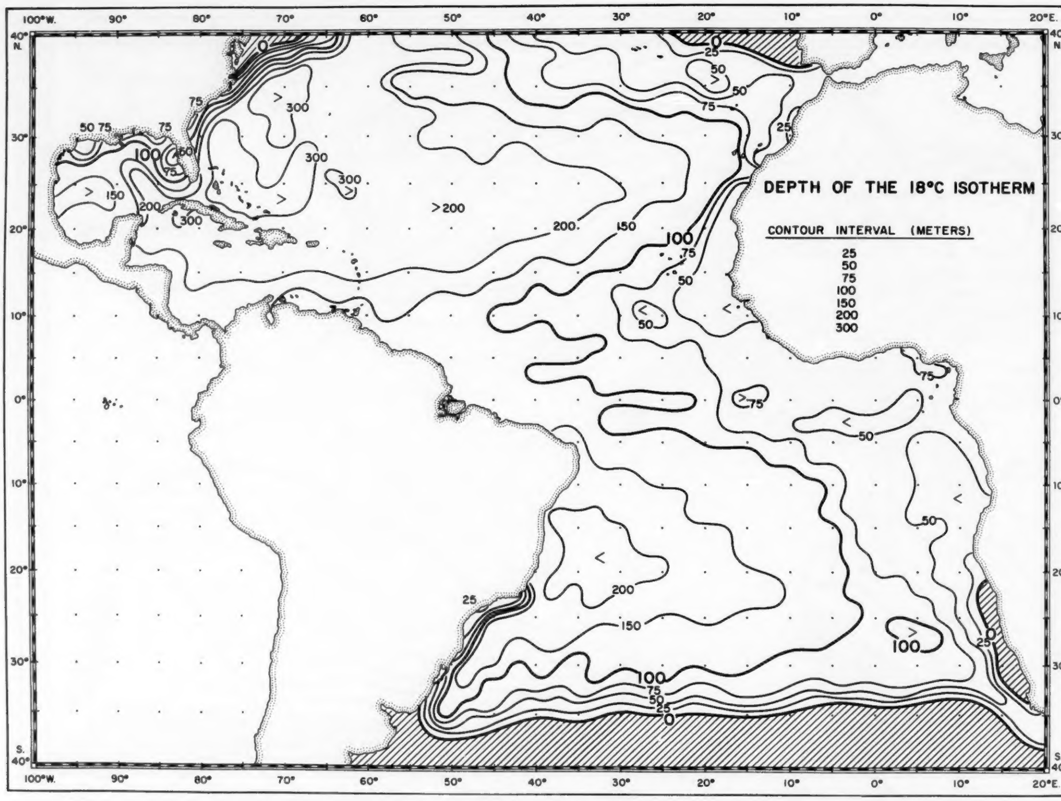

Figure 6.—Long-term annual mean depth of the 18°C isotherm. Hatched areas are colder than 18°C at all depths.

the second habitat constraining parameter, display similar large-scale features. As with the depth of the 18°C isotherm, the 3.5 ml/l surface is shallow in the eastern Atlantic, becoming deeper to the west. This layer also deepens poleward from the tropics due to higher dissolved oxygen capacity of colder water. A trough in the 3.5 ml/l surface symmetric about the Equator appears to be associated with the equatorial undercurrent. As with the 18°C isotherm, coastal upwelling causes shoaling of the 3.5 ml/l surface in the areas off southwest and northwest Africa and southern Brazil. For the areas off Argentina, northern Brazil, and Venezuela, shoaling of the 3.5 ml/l surface may not be caused by upwelling in the immediate area but rather by an increase in primary productivity associated with the advection of upwelled waters out of the source area[3].

In nearshore areas high rates of primary production associated with upwelled waters inhibit light penetration. This causes a decrease in the compensation depth which in turn causes a shoaling of the near surface dissolved oxygen maximum (footnote 3) and the 3.5 ml/l surface. Advection of surface waters, and to some extent turbulent mixing, may transport nutrient-rich surface water out of the upwelling area. An example of this would be the shoal area (less than 50 m) of the 3.5 ml/l surface extending into the Atlantic from the coast of Brazil near lat. 20°S. Mascarenhas et al. (1971) indicated significant coastal upwelling as well as large cyclonic and anticyclonic eddies in this area. These findings agree with those of Reid et al. (1977) who stated that a substantial poleward flow exists just offshore of the Brazil current. These mechanisms could combine to advect substantial quantities of nutrient-rich surface water, off-

[3]See pages 85-86 in Parsons and Takahashi (1973).

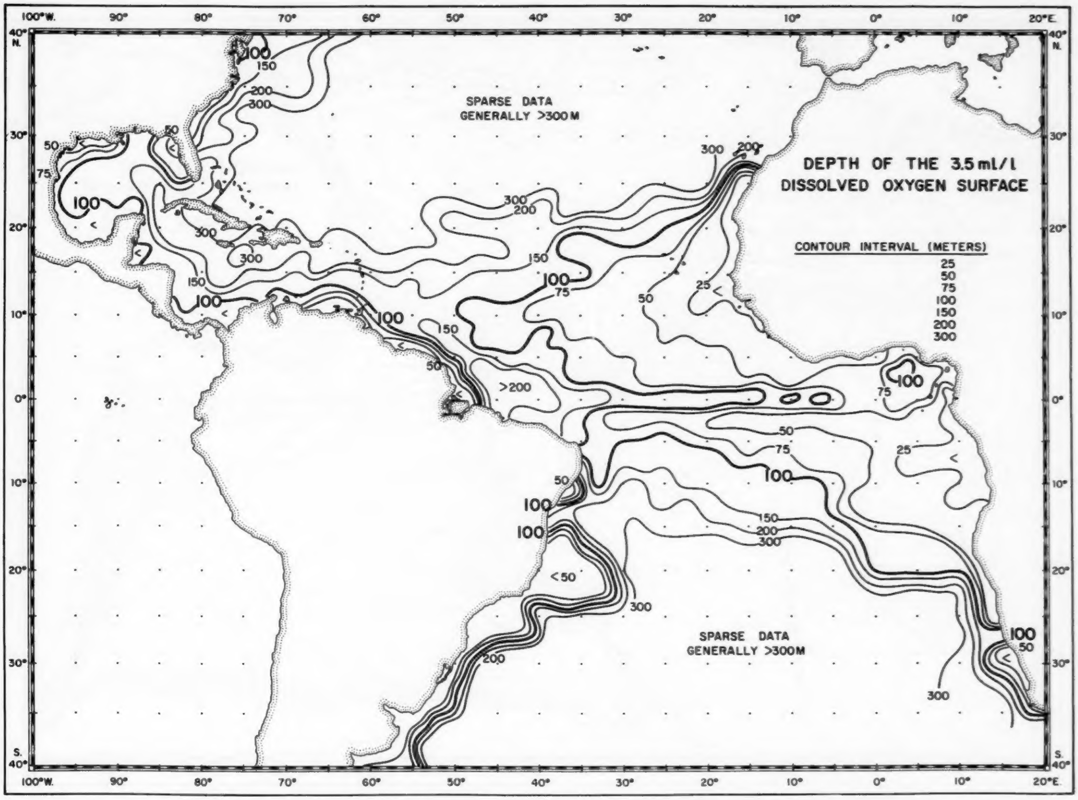

Figure 7.—Long-term annual mean depth of the 3.5 ml/l dissolved oxygen surface.

shore and equatorward in the area in question, thereby creating features in the 3.5 ml/l contours that are not consistent with or observed in the contours for the depth of the 18°C isotherm or sea surface temperature.

Figure 8 depicts the areal depth of skipjack tuna habitat indicating that skipjack tuna are capable of inhabiting almost all of the Atlantic between lat. 40°N and 34°S. Except for areas influenced by coastal upwelling, habitat depth is controlled by the depth of the 18°C surface poleward of about 15° latitude in either hemisphere. In the equatorial band (between lat. 15°N and 15°S), habitat depth is determined by dissolved oxygen concentration.

Having established that skipjack tuna can inhabit portions of the water column in most of the Atlantic between lat. 40°N and 34°S, it is necessary to define and limit those areas where skipjack tuna may be vulnerable to surface fishing gear. It seems reasonable that skipjack would be most vulnerable in those areas where their habitat is restricted to the near-surface layer. This is suggested by each of the panels in Figure 2. Figures 2A and 2B depict results of eastern tropical Pacific studies relating skipjack tuna purse seine success to the depth of the mixed (isothermal) layer. Both Figures 2A (Green, 1967) and 2B (Miller and Evans, footnote 1) utilize eastern tropical Pacific skipjack tuna purse seine data from the early 1960's and 1970's, respectively. Figure 2C (Ingham et al., 1977) compares Atlantic research ship sightings of surface skipjack tuna schools to oxycline depth.

Catch/school sighting trends with depth are remarkably similar in each panel. At depths shallower than the "critical depth" (defined as the mode of each of the distributions in Figure 2), catch and school sightings drop off markedly. At depths greater than the "critical depth," catch and school sightings drop off more slowly and in an exponential fashion as is indicated by the log

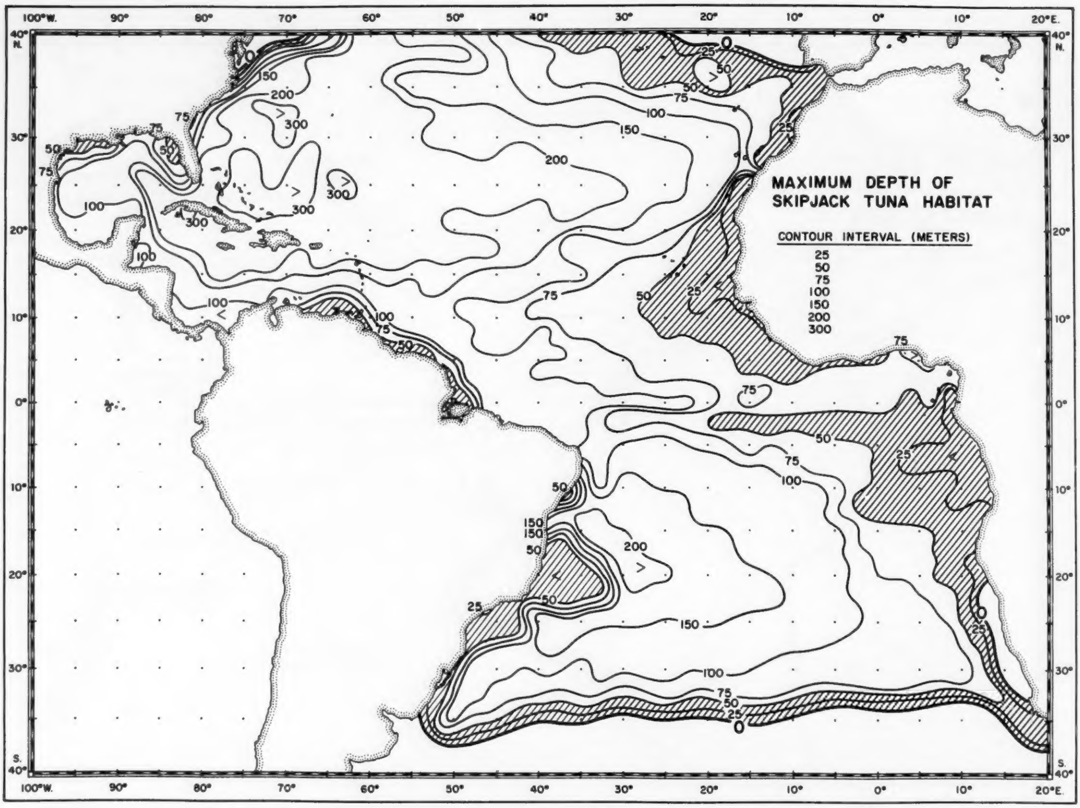

Figure 8.—Annual mean contours of maximum depth of skipjack tuna habitat, derived from graphical integration of Figures 6 and 7. Hatched areas indicate depths less than 50 m.

curve which has been fitted in each case. This suggests that skipjack tuna are less vulnerable in areas where the habitat depth is shallower than the critical depth (10-15 m). Decreased vulnerability in these shallow layers may be due to avoidance of such a constrained environment for possibly habitat layers shallower than 10-15 m do not routinely exist in nature. At habitat depths deeper than 10-15 m skipjack tuna catch/school sightings fall off more slowly. This decrease in vulnerability may be due to a simple increase in habitat volume.

For all three of the studies depicted in Figure 2, catch or school sightings are zero or extremely small for mixed layer or oxycline depths deeper than 50 m. It can be reasonably concluded, therefore, that skipjack tuna are not vulnerable to surface fishing gear or detection in areas where either of these parameters exceeds 50 m depth.

To examine this hypothesis, equivalence of oxycline and mixed layer depths to the 3.5 ml/l and 18°C surfaces, respectively, must be established. In this regard, the criteria used to define the oxycline in Figure 2C is the 3.5 ml/l surface (Ingham et al., 1977). Where the lower habitat limit is the 18°C isotherm it will by definition be equal to or deeper than the mixed layer depth. Therefore, the habitat depth will be either coincident with or somewhat deeper than the oxycline or mixed layer depth. Consequently, a habitat depth of 50 m would seem a reasonable assumed limit of vulnerability of skipjack tuna to surface gear.

To test the validity of a maximum depth of vulnerability, the 50 m habitat depth contour was plotted over the catch distribution for skipjack tuna for the FIS fleet for 1969-1977 (Fig. 4). Essentially all the catch falls in areas where the habitat depth is less than 50 m. A notable exception occurs in a nar-

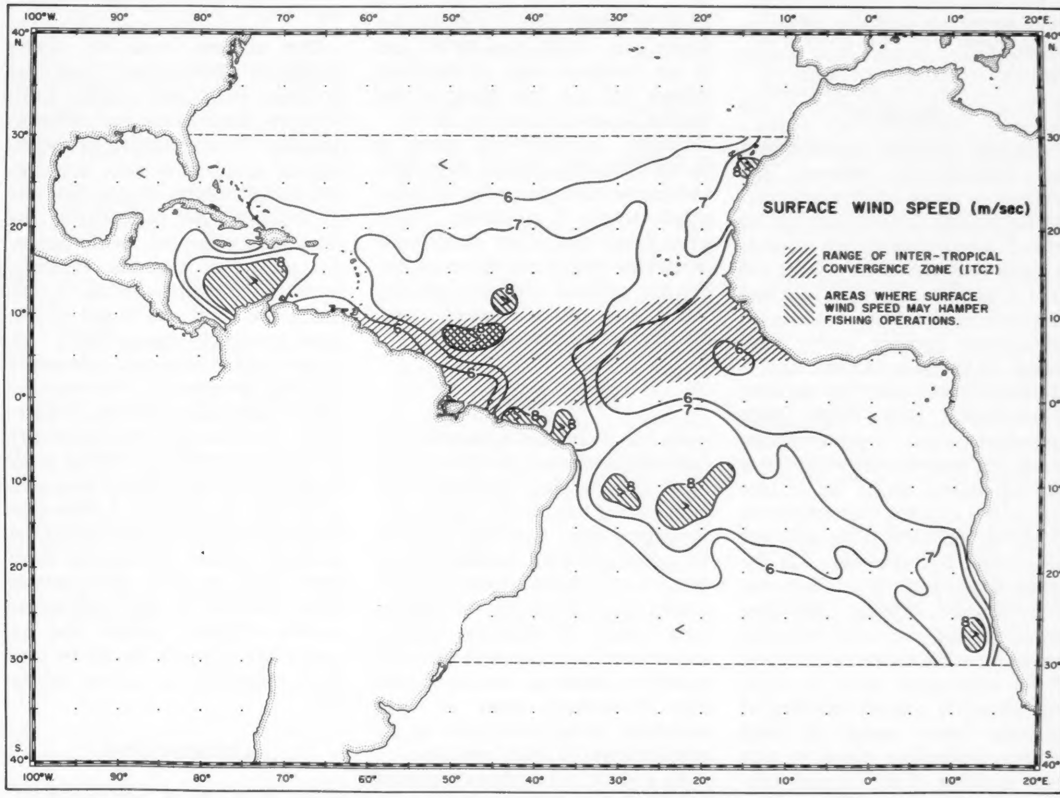

Figure 9.—Long-term mean annual contours of the seasonal range of selected sea surface wind speed values (m/second). Hatching depicts those areas where the surface wind speed is equal to or greater than 8 m/second and/or the annual range of the Inter-Tropical Convergence Zone; based on convergence of the surface wind field.

row band just north of the Equator between the coast and long. 6° W where the habitat is 50-75 m deep (Fig. 8). This is an area of highly variable oceanographic conditions (Dietrich, 1963). It is possible that the habitat depth in this area is less than 50 m on a seasonal basis and that the indicated catch occurs during these periods.

A maximum depth (50 m) of vulnerability of skipjack tuna to surface gear is indicated by hatching in Figure 8. As indicated, several areas in the western Atlantic have habitat depths appropriate for skipjack tuna vulnerability to surface gear (Fig. 8) including: 1) Off Argentina and along the south coast of Brazil, 2) off Venezuela and along the north coast of Brazil, 3) along the northern half of the Gulf Stream off the United States, and 4) along a band extending northwestward from the northwest African coast.

As previously indicated, surface wind speed can seriously restrict fishing operations and thereby the catchability of skipjack tuna by surface gear. Since purse seining success falls off markedly at wind speeds above 8 m/second (Fig. 3), that value has been taken as critical and areas where wind speed may exceed that value during the year have been hatched in Figure 9. Of those areas having high wind conditions only the area off Africa at lat. 28°S is coincident with an area where the skipjack tuna habitat depth is less than 50 m.

Figure 9 also includes the annual range of position of the Inter-Tropical Convergence Zone (ITCZ); that region where easterly trade winds from the northern and southern hemispheres meet. The ITCZ is traditionally an area of alternately squally, severe weather and light winds. Fishermen purse seining for tuna in the tropical

Pacific often fish in the area of light winds found on occasion adjacent to the ITCZ.

Conclusions

Previous research demonstrates that relationships between the behavior or catch of skipjack tuna and the marine environment can be defined. An analysis of this research indicates that the depth of the 3.5 ml/l dissolved oxygen surface and the depth of the 18°C isotherm in combination provide viable constraints on skipjack habitat. Applying these constraints to existing environmental data fields yields three-dimensional representations of skipjack tuna habitat which show that: 1) Almost all of the surface layer of the Atlantic Ocean between lat. 40°N and 34°S is suitable for habitation by skipjack; 2) the habitat depth or floor is shallowest in the eastern Atlantic, becoming deeper toward the west with the deepest areas occurring at the center of the subtropical gyres in either hemisphere; 3) coastal upwelling of nutrients feeds areas of high primary production which in turn cause shoaling of the oxygen maximum layer, the 3.5 ml/l surface and the habitat floor; and 4) advection and turbulent mixing may tend to displace areas of shoaling associated with primary production away from the upwelling source area.

Definition of skipjack tuna habitat does not imply they will be vulnerable to surface fishing gear throughout their range. Previous studies suggest that skipjack tuna cease to be vulnerable to surface gear at habitat depths in excess of 50 m. This concept is tested with favorable results against the catch by surface gear of the FIS fleet and then extrapolated to the western Atlantic to determine areas of high expected vulnerability.

The areas of high potential skipjack vulnerability in the western Atlantic include: 1) The nearshore regions off the east coasts of Brazil and Argentina between lat. 16°S and 32°S, 2) the areas off the north coast of Brazil and Venezuela between long. 48°W and 68°W, and 3) the northern edge of the Gulf Stream off the east coast of the United States north of lat. 35° N.

Finally, surface wind speed is shown to hamper fishing operations with purse seine gear when the wind speed exceeds 8 m/second. Those areas where the vector mean wind speed may exceed this value seasonally are outlined and are generally found to lie outside areas of potential skipjack vulnerability.

Future Research

At this point it is appropriate to indicate that the use of annual mean oceanographic data to define skipjack habitat has certain drawbacks. Averaging over extended scales in both time and space can have the effect of: 1) Masking seasonal and spatial fluctuations in the various data fields, 2) allowing extreme values in a locale (in both time and space) to dominate annual signals, and 3) causing areas of high variability in the data fields to appear constant in space and time.

As a result, the analyses presented herein may fail to depict or sometimes misrepresent skipjack tuna habitat over small areas or where only seasonal vulnerability occurs. A case in point is that area of the Caribbean just to the west of the Lesser Antilles where turbulence from flow through the island arc and over shoal areas during March and April causes skipjack tuna to be locally vulnerable to surface gear (Ingham and Mahnken, 1966).

This does not mean, however, that the approach of using annual averaged data is invalid. On the contrary, the analyses in this paper provide an overview of conditions for the entire Atlantic. As such, they contain useful information for resource exploitation and management and aids for determining those areas to which further research addressing shorter time scales should be directed.

Acknowledgments

The authors wish to thank Margaret Robinson, Compass Systems, Inc., and Joseph Reid, Scripps Institution of Oceanography. Their considerable knowledge of archived oceanic temperature and dissolved oxygen data was an invaluable aid in analyzing the data fields presented in this paper. The efforts of Lorraine Prescott, Southwest Fisheries Center, in preparing the numerous drafts of this paper are deeply appreciated.

Note added in proof: This paper was first presented to the International Commission for the Conservation of Atlantic Tunas (ICCAT) in November 1979. In 1980 the catch of skipjack tuna by Brazil increased more than threefold to 7,000 t (ICCAT preliminary figures). All of the increased catch appears to have come from an area off southern Brazil defined by the authors as suitable skipjack habitat and an area where skipjack should be routinely vulnerable to surface fishing gear.

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Burnt Tuna: Conditions Leading to Rapid Deterioration in the Quality of Raw Tuna

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A. E. DIZON, AND W. N. IKEHARA

Introduction

In Hawaii, raw tuna flesh which seems paler and softer than normal is characterized by buyers as being "burnt." High-quality tuna should be translucent, red, and firm. Burnt tuna, because of its poor texture, color, and slightly sour taste, while edible, is undesirable for raw consumption (as "sashimi"). It therefore commands only a fraction of the selling price of high quality tuna, depending on the extent and the severity of burn. However, the burnt condition is not absolute in extent or degree; the affected area can vary from 5 to 100 percent of the total marketable meat of the fish and range in severity from marginal to severely burnt. The variability in occurrence compounds an already difficult diagnostic problem.

The condition periodically occurs in the large (45-136 kg) tropical tunas—the yellowfin tuna, *Thunnus albacares,* and bigeye tuna, *T. obesus*—and was first brought to the attention of the National Marine Fisheries Service (NMFS) in 1974 by recreational fishermen who troll off Hawaii's Kona coast. The problem is now a major economic concern of the night handline fishery of the same island. This highly effective, cost efficient industry, found only in Hawaii and in the Philippines (Yuen, 1979), would be an excellent candidate for fishery development in export-poor Pacific island nations if the burn problem could be controlled. Whatever the causes of burn, we suspect that the problem is exacerbated by the limited chilling facilities found aboard most night handline and recreational fishing boats.

In Hawaii, traditional marketing practices delay the discovery of burn. A typical fish changes hands at least twice in the first 48 hours after death. The fisherman consigns his catch to a wholesaler who then either sells it locally or ships it to a more distant market. If the fish is sold locally, the fish is butchered and the burn is discovered relatively quickly, within 12 hours of catching. However, if it is exported, butchering usually occurs after the fish is sold to the last and most distant retailer, from 36 to 60 hours after catching. Transportation costs have thus been incurred before discovery of the condition.

Upon discovery of burn, the fisherman is required to refund a portion of the auction price to the wholesalers which is then used to defray a fraction of the costs involved in the marketing and shipping. Rebates on burnt fish were reported to range from 5 to 75 percent of the original selling price in 1977. Annual losses to the night handline fishermen were estimated to be about 16 percent of the total value of the catch (Cramer et al.)[1].

Clearly the reduction of burn through improved fishing and handling methods is an important goal and some method must be developed to identify the condition of the fish early in the marketing sequence before filleting.

These requirements formed the motivation for our work. We reasoned that our best strategy to investigate burn was to correlate quality of the fish with those measurable variables that would be likely to be responsible for, or at least indicate burn. Those correlates fell into three classes: 1) Fishing variables such as time of the year, temperature of the water, fighting time, and care of the catch; 2) biological characteristics such as sex, weight, species, and body temperature at death and after; and 3) biochemical, histological, and pH samples. We hoped that burnt fish would exhibit some differences in key characters relating to exercise or flesh quality. Thus, differences between burnt and normal tuna

ABSTRACT—Burnt tuna is raw tuna which is paler and softer than normal. This study indicates that the burnt tuna condition results from muscle cell degeneration which begins prior to the death of the fish and proceeds more rapidly after death than in normal tuna. Female sex, longer fighting times, and less efficient chilling are positively correlated with the occurrence and severity of the burnt tuna condition.

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[1]Cramer, J. L., R. S. Shomura, and H. S. H. Yuen. 1978. The problem of burnt tuna in the Hawaiian fishery. National Marine Fisheries Service, Southwest Fisheries Center Admin. Rep. 11H, 17 p.

would indicate the causes and suggest remedies.

Materials and Methods

Fish

Bigeye and yellowfin tunas were studied in this report. Three tunas were obtained from commercial fishermen on the island of Hawaii. Seven fish were caught off Kona, Hawaii, and transported live in the baitwell to the Kewalo Research Facility (KRF) in Honolulu and two fish were held in captivity at KRF for over 6 months before being used in these studies.

The date, area of catch, fighting time, weight, species, and sex of the fish were recorded. The prechill interval (the time from landing to chilling) was also recorded.

Sampling and Testing

Temperature, blood, and muscle samples were recorded when the fish were: 1) First landed on the boat, 2) off-loaded from the boats, and 3) at 24 hours after off-loading.

Blood was obtained by cardiac puncture immediately after boating the fish using silicone-coated vacutainers (Kimble-Terumo, Elkton, MD.).[2] Captive fish were bled just prior to killing, and 2 ml of whole blood were immediately mixed with 2 ml of 15 percent perchloric acid for glucose and lactate determinations. The serum was separated from the remaining blood and frozen for later testing.

A coring tool was used to obtain tissue samples from the deep muscle near the vertebral column. Tissues were frozen on dry ice or fixed in Dietrich's solution. The latter tissues were processed to obtain Hemotoxylin and Eosin stained sections for microscopic examination.

An electronic thermometer with a 12 cm probe was used to obtain temperatures of deep (11 cm) or superficial (just under the skin) tissues of fish.

Fish held in captivity or transported live to KRF were placed in ice water for 4-8 hours after killing to simulate normal commercial procedures for treatment of fish prior to off-loading.

The handling of fish during the first 24 hours after off-loading from the boats was evaluated and categorized. The fish were designated to have received: 1) Excellent treatment when stored in ice water at 0°C, 2) fair treatment when stored in refrigerators at 5°C, and 3) poor treatment when stored at ambient temperature of 28°C.

After the fish were auctioned and quartered, the flesh was graded and scored on the basis of color and texture as: Excellent, 1 point; good, 2 points; marginal, 3 points; poor, 4 points; and very poor, 5 points. These subjective evaluations were corroborated by discussions with the auctioneer and correlated with the price received per pound of fish.

Tests

Blood lactate and glucose concentrations were determined by enzymatic analysis utilizing the conversion of NAD to NADH as described by Burgmeyer (1974). A creatine phosphokinase (CPK) assay was also conducted following the method of Burgmeyer (1974). The above assays were performed at the University of British Columbia, Vancouver, with the direction and assistance of P. Hochachka and J. Balantyne.

The pH of muscle tissue was determined by titration and the amount of potassium carbonate required to lower the pH of the muscle suspension to a pH of 5.6-6.0. A pH meter with a 4 mm diameter probe was used to determine the pH of the midsection and tail muscle tissue of yellowfin or bigeye tuna on the auction floor. The pH was also determined by pH meter for macerated muscle tissue suspended in distilled water.

Statistical Analysis

Correlations of quantitative variables were determined by simple regression analysis. Correlations involving one or more nonparametric variables were determined by using Spearman's correlation rank test (Snedecor and Cochran, 1967).

The significance of differences between mean values were determined using a t test for the differences of means (Snedecor and Cochran, 1967).

Results

The fighting time and other relevant data on the 12 fish used in this study are recorded in Table 1. Significant ($P<0.05$) positive correlations were found between fighting time and concentrations of blood lactate (Fig. 1) and blood glucose (Fig. 2) at death and between fighting time and tissue lactate (Fig. 3) when fish were being off-loaded from the boats. A negative correlation was found between fighting time and relative acidity of muscle at off-loading (Table 2). The correlations of these parameters are also indicated in Table 2.

There was a significant difference ($P<0.05$) between sexes in quality of flesh of fish over 30 kg in weight (Table 3). The flesh of female fish was more often of low quality. An interaction was found between

Table 1.—Data on fish studied.

Date caught (1978)	Area caught	Fighting time (min.)	Wt. (kg)	Species	Sex
21 Aug.	Hilo[1]	9	115.8	*T. albacares*	M
21 Aug.	Hilo[1]	10	63.6	*T. albacares*	F
27 Sept.	Kewalo[2]	15	10.8	*T. albacares*	F
27 Sept.	Kona[2]	9	5.2	*T. obesus*	M
27 Sept.	Kona[3]	9	4.4	*T. obesus*	M
27 Sept.	Kona[3]	4	3.4	*T. albacares*	F
27 Sept.	Kona[3]	4	3.5	*T. albacares*	F
27 Sept.	Kona[3]	12	3.7	*T. albacares*	M
27 Sept.	Kona[3]	18	3.6	*T. albacares*	M
27 Sept.	Kona[3]	31	3.5	*T. albacares*	F
17 Oct.	Kewalo[2]	0	9.4	*T. albacares*	F
23 Oct.	Kona[1]	15	50.4	*T. obesus*	F

[1]Sampled at sea.
[2]Captive fish.
[3]Transported live to KRF.

[2]Reference to trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

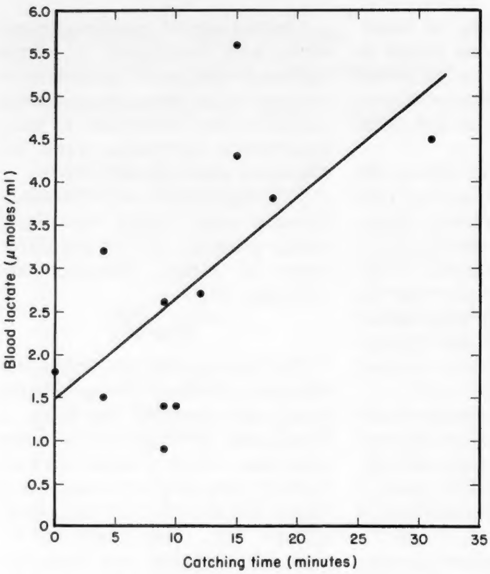

Figure 1.—Correlation between catching time (fighting time) and concentration of blood lactate at death. Line fitted by least squares methods.

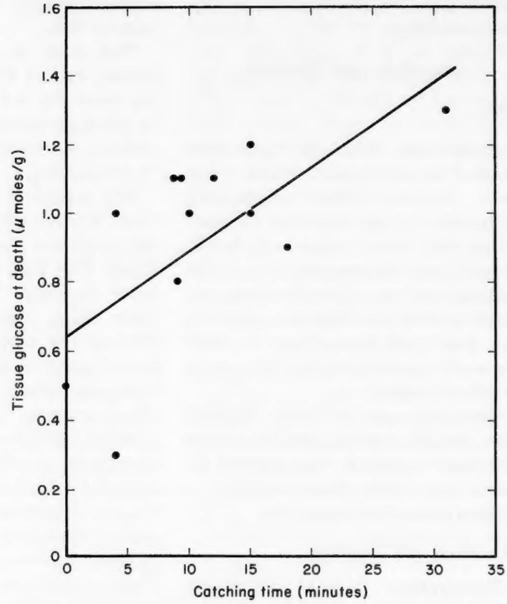

Figure 2.—Correlation between catching time (fighting time) and concentration of glucose at death. Line fitted by least squares methods.

Table 2.—Correlations between fighting time (FT), blood lactate level at death (BL), tissue glucose level at death (TGa), tissue lactate level at off-loading (TLb), relative acidity in tuna tissues at off-loading (TAb), and quality of fish at quartering (Q).

Independent variable	Dependent variable	Correlation
FT	BL	[1]0.64
FT	TGa	[1]0.69
FT	TLb	[1]0.59
FT	TAb	[1]-0.66
BL	Q	[2]0.82

[1]Significant at the 0.05 percent level.
[2]Significant at the 0.01 percent level.

treatment after off-loading and concentrations of blood lactate at death (Table 4). Low lactate and good treatment resulted in excellent quality flesh; low lactate and poor treatment or high lactate and fair treatment resulted in marginal quality flesh; and high lactate and poor treatment produced poor quality flesh.

Table 3.—The effect of size and sex on flesh temperature and flesh quality.

Body wt. (kg)	Sex	Temperature (°C) Average	Temperature (°C) Range	Flesh quality[1] Average	Flesh quality[1] Variance
<11	M	27.5	26.9-28.4	2.4	1.3
<11	F	27.7	26-29.5	2.8	0.7
>30	M	29.6	29-31	1.5	1.0
>30	F	29.7	27-31	2.8	1.6

[1]1 = Excellent, 2 = good, 3 = marginal, 4 = poor, and 5 = very poor.

In some cases, there was excellent correlation between pH of muscle tissue and quality of tuna flesh (Table 5) while in other instances lower pH could not be correlated with poor quality flesh (Table 6, Fig. 4). These differences are probably due to differing temperatures and durations before auction (Nakamura et al., 1977).

Table 4.—Interactions between blood lactate levels at death and 24-hour treatments after off-loading.

Blood lactate micromole/ml	Quality at death[1]	Treatment[2]	Quality at quartering[1] (24 h after death)
0.91	1	Excellent	1
1.42	1	Excellent	1
1.42	1	Poor	3
1.47	1	Fair	2
1.82	2	Fair	2
2.58	2	Fair	2
2.67	1	Fair	2
3.20	2	Poor	3
2.83	1	Poor	4
4.25	3	Poor	4
4.49	2	Fair	3
5.64	2	Poor	4

[1]Quality was determined histologically and was scored as follows: 1 = Excellent, 2 = good, 3 = marginal, 4 = poor, and 5 = very poor.
[2]Excellent = stored in ice water at 0°C, fair = stored in refrigerators at 5°C, and poor = stored at ambient temperature of 28°C.

No significant correlations were found between deep body temperatures and quality of fish or results of biochemical tests. Nor could signifi-

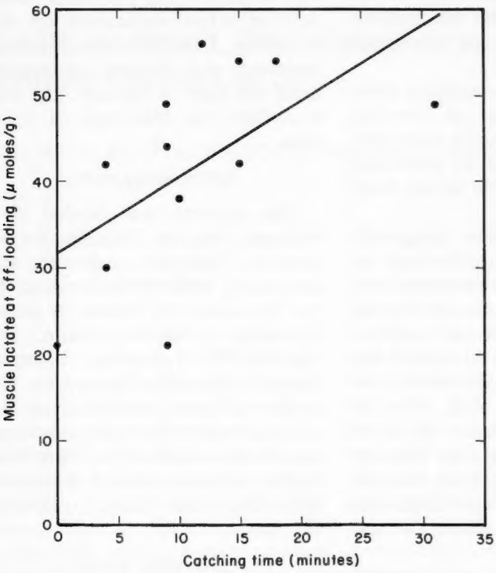

Figure 3.—Correlation between catching time (fighting time) and muscle lactate at off-loading. Line fitted by least squares methods.

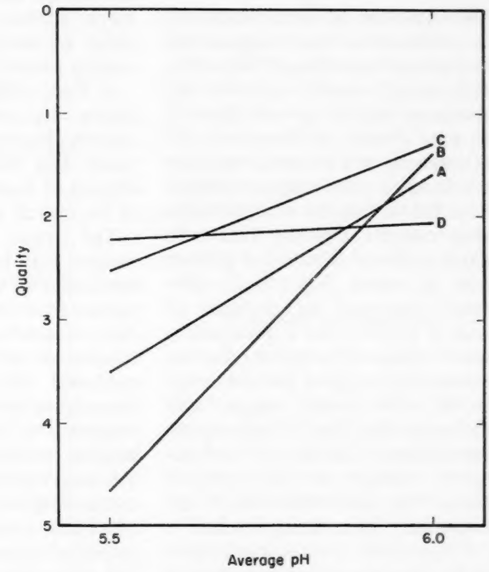

Figure 4.—Correlation between pH and auction quality (1 = excellent, 2 = good, 3 = marginal, 4 = poor, and 5 = very poor) of: A) all fish sampled, B) fish sampled on 28 July, C) Honolulu fish sampled on 10 August, and D) Hilo fish sampled on 10 August.

Table 5.—Quality and pH of midsections and tails of yellowfin tuna at the Honolulu fish auction, 28 July 1978.

	Tuna quality									
	Excellent		Good		Marginal		Poor		Very Poor	
	Mids	Tail	Mids	Tail	Mids	Tail	Mids	Tail	Mids	Tail
	6.0	6.1	6.0	6.2	5.6	5.7	5.6	5.6	5.4	5.5
	6.0	6.0	5.9	5.6	—	—	5.7	5.8	5.5	5.6
	6.0	5.7	5.9	5.9	—	—	5.8	5.9	5.7	5.8
	5.8	5.9	5.8	5.9	—	—	5.7	5.9	—	—
	6.0	5.6	—	—	—	—	5.6	5.7	—	—
	5.8	6.0	—	—	—	—	—	—	—	—
	5.9	6.0	—	—	—	—	—	—	—	—
Mean	5.93	5.90	5.90	5.90	—	—	5.68	5.78	5.53	5.63
Variance	0.01	0.03	0.01	0.06	—	—	0.01	0.02	0.03	0.03

cant correlations be found between the pre-chill interval and quality of fish or results of biochemical tests of blood and tissues.

Histopathologic studies of muscle from a limited number of fish revealed the following: 1) Inflammatory changes were not seen, suggesting that all changes occurred shortly before or immediately after death; 2) edema was seen in muscle obtained at the time of boating; 3) extensive edema and muscular degeneration were seen in burnt fish at the time of auctioning; and 4) tissue gram stain showed that bacteria was associated with the muscular degenerative changes.

Table 6.—Quality and pH of midsections and tails of yellowfin tuna at the Honolulu and Hilo fish auctions, 10 August 1978.

	Tuna quality					
	Excellent		Good		Poor	
	Mids	Tail	Mids	Tail	Mids	Tail
	Honolulu fish					
	5.6	5.6	5.5	5.6	6.0	5.5
	5.6	5.7	5.7	5.7	5.9	5.8
	5.9	5.9	5.6	5.7	—	—
	5.6	5.7	—	—	—	—
	5.7	5.8	—	—	—	—
Mean	5.68	5.74	5.60	5.67	5.95	5.65
Variance	0.2	0.01	0.01	0.00	0.08	0.02
	Hilo fish					
	5.8	5.9	5.8	5.8	5.7	5.8
	6.0	5.9	5.7	5.8	5.9	5.8
	—	—	5.9	5.9	—	—
	—	—	5.7	5.8	—	—
	—	—	5.9	5.9	—	—
	—	—	6.0	6.0	—	—
	—	—	5.8	5.8	—	—
	—	—	6.0	6.0	—	—
	—	—	6.0	6.1	—	—
	—	—	6.0	5.9	—	—
	—	—	6.1	6.1	—	—
	—	—	5.9	5.9	—	—
Mean	5.90	5.90	5.90	5.92	5.80	5.80
Variance	0.02	0.00	0.02	0.01	0.02	0.00

Discussion

As suspected by tuna fishermen, the results of this study suggest that the care and handling of fish after being caught is partly related to the subsequent quality of the flesh of the tuna (Table 4). However, the pathogenesis of burnt tuna may also be related to physiological changes in the fish during the struggle while being caught. Fighting time was related to blood lactate and glucose levels at death (Fig. 1, 2). The edema (abnormal accumulation of fluid) in muscle seen in histopathological studies of biopsies obtained at death also suggest that the struggle of fish being caught may predispose the flesh to subsequent degeneration. The lack of inflammatory changes at that time indicates that the condition is not developed prior to being hooked.

A hypothesis on the mechanism for the development of burnt tuna is as follows.

1) The struggle of fish while being caught may result in muscle edema, the severity depending on the intensity of the struggle. (Longer and more intensive struggling results in higher blood levels of glucose and lactate.)

2) The edema fluid of muscle presents a good medium for bacterial growth.

3) Chilling of fish after catching determines the temperature of the deeper portions of the fish muscles, which are least affected by external cooling procedures.

4) Poor chilling procedures allow higher temperatures in muscle, allowing bacteria to grow more profusely and resulting in increasing degrees of burn in the deeper areas of the muscle mass.

The most reliable diagnostic method may be histopathologic examination of biopsy specimens obtained from deep muscle tissues, flash frozen, sectioned with a cryostat at the auction, stained and examined. All of this can be accomplished in 0.5-1 hour. With the exception of tests made on blood samples collected at the time of catching, biochemical tests were not useful in prediction and diagnosing the burnt tuna condition of unquartered tuna.

A stress-induced abnormality which occurs in hog muscle known as porcine stress syndrome (Winstanley, 1979) seems similar in some characteristics to burnt tuna. Both conditions result in pale and soft muscles. It is possible that there may be related causes for the two conditions.

It is obvious that further studies on burnt tuna are necessary. The small number of fish sampled in this study (12) resulted in possible leads and solutions, but precludes strong and definitive statements on this condition. It is likely that improved handling and chilling procedures from the time of capture may help to reduce the incidence of burnt tuna.

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Quality of Squid, *Illex illecebrosus*, Mantles Canned in Oil

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Introduction

Squid meat is equal to fish meat in protein content (16-20 percent) and amino acid composition and can be considered as an excellent source of protein (Takahashi, 1965). Compared with other marine animals eaten by man, squid provide a relatively higher yield of edible parts. With vertebrate fishes, the recoverable edible portion ranges from 20 to 50 percent; and in the commonly eaten shellfish, the edible parts are from 20 to 40 percent. In squid, the edible portion, which consists of the mantle, fins, and tentacles, is from 60 to 80 percent of the weight of the animal, depending on the species and its size (Ampola, 1974). In this period when more abundant food resources are urgently needed, it is time for concerted action for the utilization of squid in the United States.

The utilization of squid from the New England squid fishery has been limited to supplying bait for domestic fishing or frozen whole for sale on foreign markets. For centuries, squid have been used as an important and palatable source of food in the countries bordering the Mediterranean Sea and in the Orient. There has been considerable market resistance on the part of the U.S. consumer who has been slow to try nontraditional seafoods. The present day U.S. consumer is well oriented to processed foods and will accept a growing variety of foods if they are made ready for use either through the canning or freezing process. Frozen breaded squid shows promise as a consumer item. Studies by marketing personnel of the National Marine Fisheries Service and by personnel at the NMFS Northeast Utilization Research Center indicate excellent acceptance of this product (Ampola, 1974).

The only commercially canned squid product produced in the United States is canned with or without its ink in brine, in oil, and in tomato sauce and this is used essentially in ethnic markets (Ampola, 1974). A satisfactory canned squid product must be developed as frozen foods cannot serve the needs of all merchandizing and consumption patterns. The canning of squid will require considerable research to determine portions of squid and processing procedures that will result in an acceptable consumer product. We believe that canning of squid must follow the direction of the frozen squid industry and utilize selected portions of the squid.

The objectives of this investigation were to examine the extent of shrinkage during thermal processing of squid mantles, to evaluate the quality of canned mantle strips, to determine the shelf life of the canned product, and to examine the effect of preprocess frozen storage conditions on the quality of the canned material.

Materials and Methods

Fresh squid, *Illex illecebrosus*, were obtained from a fisherman on the day of catch or on the second day of catch from a processor. At all times the squid were iced well. Frozen squid were obtained in 4.54 kg (10-pound) blocks measuring 6.4 ×23.5×31.8 cm (2.5×9.25×12.5 inches) which were blast frozen by the processor at -34.4°C (-30°F) and stored at -20.5° to -23.3°C (-5° to -10°F) for 1 month before purchase. In the laboratory the frozen squid were thawed for 24 hours at 7.2°C (45°F) before being taken to the pilot plant for further processing.

Commercially frozen squid were used to determine the effect of polyphosphate on shrinkage. The effects of citrate and frozen storage on the quality of the canned product were also studied using commercially frozen squid. The remainder of the experiments were performed using fresh squid.

Cleaned squid mantles with fins and skin removed were blanched in a boiling solution of 1 and 3 percent NaCl with or without sodium tripolyphosphate or citric acid. The mantles were cooled, cut in 1.5 cm

ABSTRACT—Squid, Illex illecebrosus, *mantles with skin removed were canned in oil, using quarter-pound aluminum sardine cans. The product had a good appearance, a mild flavor, and a firm texture; however, the mantles required blanching prior to canning. Ten minute blanching in 3 percent boiling brine resulted in about 45 percent shrinkage. Addition of polyphosphate to the blanch water did not reduce shrinkage. Presence of citric acid in blanch water or the use of different oils in the can did not improve the quality of the canned mantle strips. Frozen storage temperature (-23° and -40°C) of the raw material had no significant effect on the quality of the canned product. Squid mantle strips canned in oil had an acceptable shelf life.*

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wide strips, placed in rectangular aluminum cans (405 × 301 × 014.5 inches) and 20 ml of oil were added. The cans were sealed without vacuum and retorted 45 minutes at 115.5°C (240°F).

Shrinkage was determined on large samples (about 3 kg) and dry weight on several small samples (about 100 g) by weighing before and after blanching and retorting. Vacuum ovens at 70°C were used for drying.

Heat penetration was determined by inserting flexible thermocouples in a squid mantle strip located in the geometric center of the can and recording the temperature of the different cans at 15-second intervals, using a Minneapolis-Honeywell[1] multipoint recorder (Model 153 × 64P16-X-41). Eight thermocouples were used to monitor the canned material and two to monitor the retort. The cycle was repeated at 4-minute intervals. Process time was calculated using the heat penetration data of the coldest can according to the formula method of Ball (National Canners Association, 1968).

Bellows-Valvair hydraulics (Model DC-50A) equipped with a 100-pound transducer (Daytronic Corp., Model 152A), and X-Y recorder (Mosley, division of Hewlett-Packard, Model 135A), and a single blade shear cell (Food Technology Corp., Model CA-1) were used to determine texture of 6 cm long mantle strips (raw and processed).

Coded samples were presented in a randomized complete block design with three replications to a sensory panel of six members. Appearance, odor, and flavor were evaluated on a 6-point scale with 5 representing the best quality product and 2 or less denoting unacceptable samples. Texture was scored on a 5-point scale, with 3 representing the best texture, 5 indicating tough tissue, and 1 indicating very soft mantles.

Results and Discussion

Yield data for various anatomical parts of squid, *Illex illecebrosus*, are given in Table 1. The edible parts, which include mantles, fins, and tentacles, represent about 66 percent of the total weight of squid. The total edible portions (62 percent) reported by Schwartz (1972) as well as individual weights (33, 9, and 20 percent) of various anatomical parts (mantle, fins, and tentacles, respectively) compare closely with the data presented here. Data reported by Berk (1974) were significantly higher for total edible parts (75 percent) for the same species of squid caught off the New England coast. This difference is due to heavier mantles (47 percent) and fins (14 percent), but the tentacles accounted for a smaller portion of the total weight (14 percent). Estimate of edible parts of squid excludes the weight of the head, although in practice the consumer is known to remove the eyes, beak, and cartilage from the head portion, thus recovering additional edible meat.

Shrinkage During Thermal Processing

Packing raw mantle strips in oil and retorting 35 minutes at 115.5°C (240°F) resulted in a 38 percent shrinkage. (Heat penetration of this pack was performed in this laboratory; f_h = 10.0 minutes.) A similar loss in weight (31 percent) was reported by Berk (1974) for mantles canned in 2 percent brine using No. 1 picnic cans and retorting 40 minutes at 115°C (239°F). Since the above product was not acceptable for commercial markets due to excessive shrinkage, Berk (1974) recommended a 2-minute blanch at 65°C prior to canning. This investigator reported a 6 percent shrinkage during blanching and an additional 10 percent shrinkage during canning with an overall loss of 15 percent of the total weight. Heating mantle strips to an internal temperature of 65°C for 2 minutes was observed in the present study to result in a 33 percent shrinkage, with an additional weight loss of 34 percent during retorting. Such a product was not considered acceptable and a 10-minute blanch in boiling 3 percent brine reported by Schwartz (1972) was adopted. This procedure resulted in a product which underwent minimal additional shrinkage during retorting.

A 10-minute blanch in 3 percent boiling brine was reported to result in a 37-56 percent shrinkage, depending on preprocess holding conditions (Slabyj and True, 1980). It is important to note that during blanching 15-42 percent of the dry weight of tissue is lost in the blanch water.

To evaluate the effect of polyphosphates on weight loss during blanching and subsequent canning,

Table 1.—Percent yield of anatomical parts of squid, *Illex illecebrosus*.

	September 1977		October 1977		November 1977[1]		August 1977[1]	
Anatomical parts	Percent	SD	Percent	SD	Percent	SD	Percent	SD
Mantle	33.1	2.0	[2]32.6	2.8	36.3	3.0	35.8	0.9
Fins	11.4	0.6	[2]9.4	0.8	10.2	1.1	10.7	0.6
Tentacles	22.4	2.0	22.1	2.9	20.7	2.2	25.4	2.3
Head	18.1	0.6	14.7	1.7	13.6	0.6	14.1	1.4
Viscera	14.1	2.1	15.3	2.1	20.1	3.6	12.5	2.0
Skin	—		2.8	0.4	—		—	
Pen	0.21	0.2	0.18	0.02	—		—	
Mantle length (cm)	26.5	—	25.9	1.6	25.9	2.3	24.7	1.4
Individual weight (g)	420.1	39.4	375.9	62.6	422.1	90.3	364.0	39.6
Determinations	6		12		6		5	

[1]Frozen squid.
[2]Skinned.

[1]Reference to trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

blanch waters containing 1 and 3 percent NaCl with 0, 0.3, and 1.0 percent sodium tripolyphosphate (FREEZ GARD FP-19) were used (Table 2). There was no noticeable change in shrinkage due to the phosphate concentration either during blanching or subsequent canning. However, squid mantles blanched in 1 percent brine lost on the average 37 percent of the total weight as compared with those blanched in 3 percent brine which lost 48 percent. The advantage in yield noticed when blanching in 1 percent brine is lost during canning. Additional shrinkage during canning was observed to be about 23 percent for mantles blanched in 1 percent NaCl solution, as compared with 11 percent for mantles blanched in 3 percent brine. The use of polyphosphates and different concentrations of salt in blanch waters had no significant effect on the loss of dry material during blanching, which varied between 24 and 32 percent (Table 2).

It may be of interest to indicate that commercially frozen squid held an additional 6 months at -23.3°C (-10°F) or -40°C (-40°F) were also examined. Samples held at -23.3°C lost 48±2 percent. This difference was not significant at the 5 percent level.

Table 2.—Effect of polyphosphate and salt concentration in blanch waters on shrinkage and loss of dry weight of squid, *Illex illecebrosus*, mantles.

1 percent NaCl			3 percent NaCl		
Polyphosphate			Polyphosphate		
0	0.3	1.0%	0	0.3	1.0%
Shrinkage due to blanching (%)					
37	35	39	48	46	49
Dry weight loss due to blanching (%)					
28	26	24	26	28	32
Shrinkage due to canning (%)					
23	25	22	10	13	11
Shrinkage due to blanching and canning (%)					
49	49	46	47	40	41

Quality of Canned Mantles

The linear portion of the heat penetration curve for mantle strips sealed in aluminum cans had a slope of 17.8 minutes (f_h) for squid mantles blanched 10 minutes in boiling 3 percent brine. Using the formula method of Ball (National Canners Association, 1968) with $F = 4.5$ and $z = 18$, the process time was calculated to be 40 minutes. However, since the above product was of experimental nature and since Thermal Death Time Curves were not available, process time on routine basis was set at 45 minutes.

Raw squid mantle is somewhat textured, having a rubbery-like consistency, but becomes soft upon blanching (Table 3). Additional softening of tissue upon retorting has not been observed, although the texture of mantles in the Spanish oil pack is rather soft. The color of the raw, skinned mantle is cream-like, but becomes lighter in color during blanching, provided the skin has been removed prior to blanching. Blanching mantles with the skin on, does facilitate subsequent removal of the skin, but this procedure has an undesirable effect in that the red pigment of the skin permeates the mantle tissue.

Canning mantle strips in soybean oil results in light, cream-colored tissue, and a mild aroma. Prolonged holding of refrigerated, raw squid will result in a discolored product. Bruised tissue becomes strongly discolored during blanching and retorting. Also, it becomes tough in texture and develops a "dry" taste. It was noticed that a delay in canning blanched mantles will allow development of strong odors.

Canned squid mantle strips were firm in texture and had a mild flavor. Because of the mild flavor of the canned material, it was thought desirable to evaluate the quality of the product using various vegetable oils. Mantle strips canned in cottonseed, olive, and soybean oil, when examined by a panel of judges for appearance, texture, odor, and flavor, were noted not to be significantly different at the 5 percent level ($P < 0.05$). Spanish processors add citric acid to squid tissues when canning it in natural juices (Schwartz, 1972). To evaluate the effect of citric acid on the quality of the canned material, citric acid was added to the blanch water at different concentrations (0, 0.3, and 1.0 percent). Sensory evaluation of the canned material for appearance, texture, odor, and flavor revealed no significant difference among the treatment means ($P < 0.05$).

Table 3.—Texture of skinned squid, *Illex illecebrosus*, mantles.

Item	Mantle thickness (mm)	Shear force[1] (kg/6 cm strip)	No. of determinations
Raw	4-5	51.10 (5.03)	9
Blanched	3-4	9.21 (2.17)	11
Canned in oil	3-4	9.20 (1.06)	11
Spanish oil pack	5-10	4.80 (1.16)	3

[1]Values in parentheses indicate standard deviation.

Shelf Life of Canned Mantles

Shelf life of canned squid mantles was studied using mantles canned in soybean oil. The canned material was stored at 7.2°C (45°F) for 6 months, while control samples were held for the same period at 0°C (32°F). The average sensory score for odor, appearance, and flavor of cans held at 7.2°C was 4.26±0.12 (SD), while control samples received an average score of 3.91±0.18. The average sensory scores for texture of the two lots of cans were 3.44 and 2.84, respectively. Although samples stored at 7.2°C received noticeably higher scores, this difference for individual attributes (Duncan, 1955) was statistically not significant ($P < 0.05$).

An accelerated storage study was also performed by incubating the canned material at 37.8°C (100°F) for 3 months. The average sensory score for odor, appearance, and flavor for samples held at 37.8°C was 3.26±0.21, while the similar score for control samples was 3.15±0.36. Average texture scores for the above canned mantles were

3.08 and 3.29, respectively. Again, the statistical analysis of the data indicated that the judges did not detect quality differences between the treated and control lots of canned squid mantles ($P < 0.05$).

Effect of Preprocess Frozen Storage

The effect of frozen storage of raw material on the quality of squid mantles canned in oil has been investigated using squid which was held 6 months at -23.3°C (-10°F) and -40°C (-40°F). The canned product was examined by a panel of judges for odor, appearance, texture, and flavor. The average sensory score for odor, appearance, and flavor for samples held before canning at -10°C was 3.90 ± 0.20, while the average score for samples held at -40°C was 3.68 ± 0.31. The texture scores for the two lots were 4.13 and 4.38, respectively. Statistical analysis of the data detected no significant difference ($P < 0.05$) between the two treatments of the raw material, indicating the inability of the panelists to detect quality difference due to preprocess frozen storage conditions.

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A System to Singulate and Align Squid for Packaging and Processing

D. E. BROWN, R. PAUL SINGH, and R. J. COFFELT

ABSTRACT—To reduce packaging time of whole California market squid, Loligo opalescens, *and facilitate automatic feeding of a newly developed squid cleaning machine, a system to align and singulate squid has been developed. Squid are circulated in a holding tank by water jets which also singulate and direct the squid through ducts to an alignment slide. The squid slide down the alignment ramp and are oriented mantle first. As the squid slides down the ramp, the tentacles drag, causing the body to rotate clockwise or counterclockwise and orient itself. Data are presented relating system performance to processing rates for the squid cleaning machine and the packing industry.*

Introduction

Squid is an important and inexpensive source of protein in much of the world, particularly the Orient. The current annual world catch is estimated at 450 million kg (500,000 tons) and a sustainable fishery may reach 91 billion kg (100 million tons) (Kato and Hardwick, 1975).

The appearance of whole squid in the local supermarket, where it is sold in small amounts, is considered unpleasant and unappetizing to some consumers despite the low retail price for whole squid, \$1.52-2.18/kg (\$0.69-0.99/pound). Cleaning squid by hand adds \$4.41-6.61/kg (\$2.00-3.00/pound) to the price for the restaurateur or retail consumer.

One species, *Loligo opalescens,* commonly referred to as California market squid, abounds off the U.S. west coast. It is currently packed by hand and frozen for foreign and domestic markets in 0.4, 1.3, 2.2, and 4.5 kg boxes (1, 3, 5, and 10 pound boxes). Squid is also hand packed and canned for foreign markets. Automatic weighing machines are used in packing squid to be frozen.

Most hand-packed, boxed, and frozen squid are left randomly oriented. The boxes are then weighed and adjusted to the desired weight by adding or removing individual squid. Random packing of squid which average 13/kg (5.9/pound) in a 0.4 kg (1 pound) box generally takes one worker 5-10 seconds[1].

Certain processors, in an effort to make whole, frozen squid more appealing to the consumer, align the top layer so that the squid are parallel and uniform. A clear plastic window in the box cover allows the consumer to inspect this top layer. This orientation of individual squid is done by hand before or after the boxes are weighed. One processor is currently operating a hand packing line, employing 12-15 workers, at 56.7 kg/minute (125 pounds/minute), using 2.2 kg (5 pound) boxes[2].

A machine to automatically feed squid, in a uniformly oriented condition, to the workers packaging or canning whole squid would greatly reduce packing time.

A machine to skin and eviscerate *L. opalescens* has been recently developed by Singh and Brown (1980). It automatically mounts an individual squid on a holding device. Using water jets, it skins, eviscerates, and removes the ink sac and backbone in 8 seconds. In an initial staging area the tentacles are severed and saved for consumption. The head is also removed. Squid are uniformly oriented and fed into this machine one by one, mantle first. An orientation device (Brooks and Singh, 1979) was used to feed squid into this machine. Individual squid were deposited by hand on this orientation slide as needed by the cleaning machine. It is estimated that a multihead machine (60-70 cleaning stations), using the principles of this prototype, could process 2,300 kg/hour (2.5 tons/hour). An automatic feeding device, providing oriented, individual squid to each cleaning station, would greatly aid in use of this machine by the seafood processing industry.

Materials and Methods

Our singulation technique (Fig. 1, 2) was developed to provide aligned, individual squid for processing, either packaging or cleaning. It consists of a singulation tank, a circular water tank, 0.91 m (36 inches) in diameter and 25 cm (12 inches) deep with a square, 5×5 cm (2×2 inch), duct (A, Fig. 1), leaving the tank at a tangent. The operating capacity of the tank is 210 liters (56 gallons).

The flow of water through duct A is accelerated by the action of water jet B (Fig. 1, 3). Water jet B consists

[1]DeLucca, A. 1980. State Fish Co., San Pedro, Calif. Pers. commun.
[2]Nobusada, K. 1980. Sea Products Co., Moss Landing, Calif. Pers. commun.

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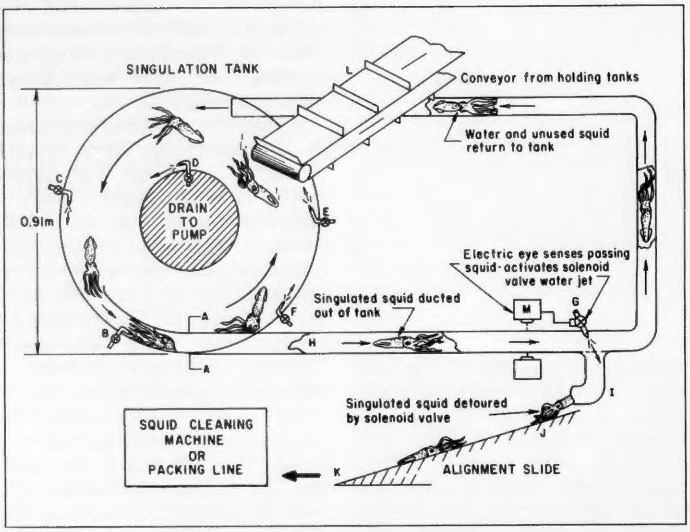

Figure 1.—System to singulate squid.

of a copper tube with an inside diameter of 1.1 cm (0.43 inch). The water flow rate through jet B was maintained at 0.33 kg/second (5.3 gallons/minute) by a centrifugal water pump. This water jet maintains the flow of water through duct A at an average velocity of 0.45 m/second (1.5 feet/second).

The water in the tank is circulated by the action of water jets C, D, E, and F (Fig. 1). These jets were made of 0.25 inch diameter copper tubing and were supplied with a valve to control the flow of water from them.

Water jet G mounted in duct H (Fig. 1) was supplied with a solenoid-controlled valve. The flow rate through it when fully developed was 0.82 kg/second (13.3 gallons/minute). Duct H is 5 cm (2 inches) in diameter. Jet G is aimed at the

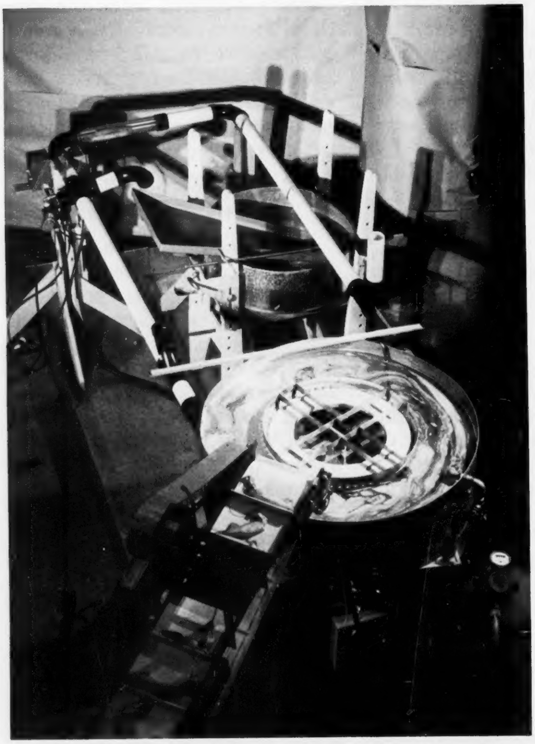

Figure 2.—Tank and duct of system to singulate squid.

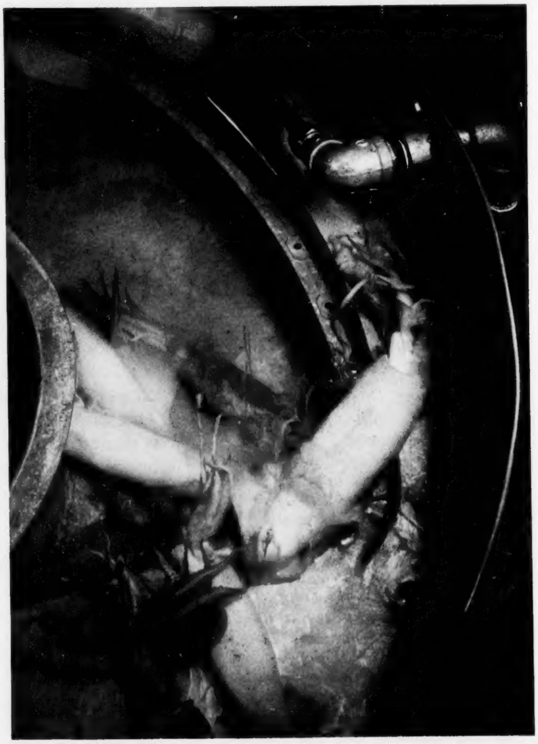

Figure 3.—Exit duct from tank and water jet B.

entrance to duct I (Fig. 1). Duct I is also 5 cm in diameter. A flow of water through duct I is developed by the flow of water from jet G when the solenoid valve is opened. Normally there is little or no flow through duct I because the centerline of the exit of duct I is elevated 5 cm (2 inches) above the centerline of duct H.

An alignment slide, J (Fig. 1), developed for orientation of squid by Brooks and Singh (1979) into a squid cleaning machine developed by Singh and Brown (1980), is located at the exit of duct I. This slide was made of PVC plastic sheet and was fixed at an angle of 20° with the horizon. This angle is close to the minimum angle recommended by Brooks and Singh (1979). A small receiving tank to represent the squid cleaning machine or packing line was positioned at the base of the slide, K (Fig. 1).

Fresh water was continually added to the system at the rate of 0.1 kg/second (1.6 gallons/minute). The overflow was drained off. This was done as a sanitation procedure.

down duct H (Fig. 1). Squid bodies remain parallel with duct H as they flow through it either mantle or tentacles-first. Their average velocity in the duct is 0.45 m/second.

Squid are diverted from duct H to duct I by water jet G (Fig. 1). An electric eye, M (Fig. 1), senses a passing squid and activates a solenoid valve which produces a powerful water jet (G) to divert the squid into duct I at a right angle to the flow in duct H.

The squid travels a short distance in duct I and is then deposited on alignment slide J (Fig. 1, 4). The friction coefficient of the squid tentacles, being higher than that of the body, causes the squid to rotate into the desired mantle-first alignment as it slides down ramp J (Fig. 1). Singh and Brown (1980) used this alignment slide to orient squid for the skinning and evisceration machine. Upon reaching location K (Fig. 1), the squid are properly aligned and ready to enter either a cleaning machine or a weighing and packaging line. The squid that are not removed from duct H by the water jet return to the tank and enter the system again.

As the numerical density of squid in the tank rises, the likelihood of two squid entering the singulation duct A simultaneously, increases. These squids are separated in the duct by the action of water jet B. Water jet B is offset to one side of the duct at A and as two squid enter the duct, they are subjected to a velocity profile difference (Fig. 5) at section A-A. The squid in the region of higher velocity accelerates past the other squid attempting to enter the duct at A with it (Fig. 6). Both squid then proceed single file.

The placement of water jets C, D, E, and F, and others not shown in Figure 1 insure that all squid are kept circulating in the tank and eventually enter duct H. In close observation throughout the development of this system we observed that all squid are removed from the singulation tank. Squid returned to the tank, not diverted to duct I because jet G is closed, are subjected to the action of water jets C through F and reenter ducts A and

Operation

Squid were batch-loaded into the singulation tank from a bucket or bin. Continuous loading was also tried using a metered belt conveyor. The density of squid in fresh tap water is 1.10 g/cc (Brooks and Singh, 1979) and, as expected, the squid sink to the bottom of the tank.

Squid are kept circulating in the tank by the action of water jets C, D, E, and F (Fig. 1). The squid, suspended in the water, are directed by the action of jets C, D, E, and F toward the exit duct A (Fig. 1, 3). The flow of water in this duct is accelerated by the action of water jet B (Fig. 1, 3). The accelerated column of water in the duct draws the squid, suspended in the water, which have been directed to the duct's entrance, out of the tank. The squid then leave the tank and flow single file

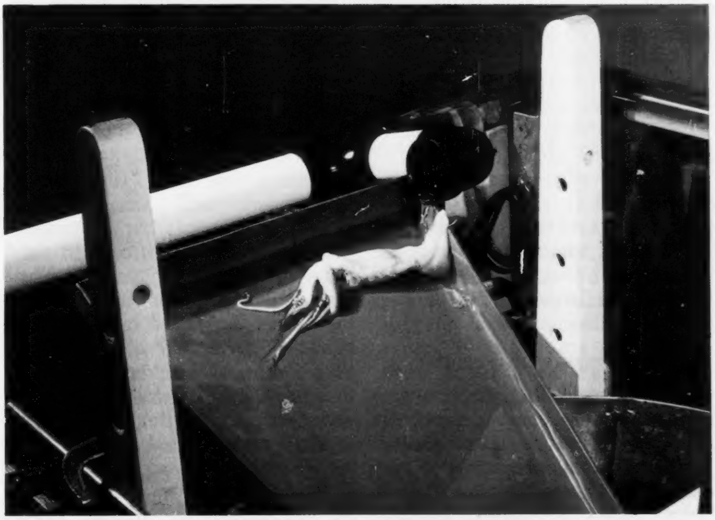

Figure 4.—Squid diverted from ducting and onto alignment slide.

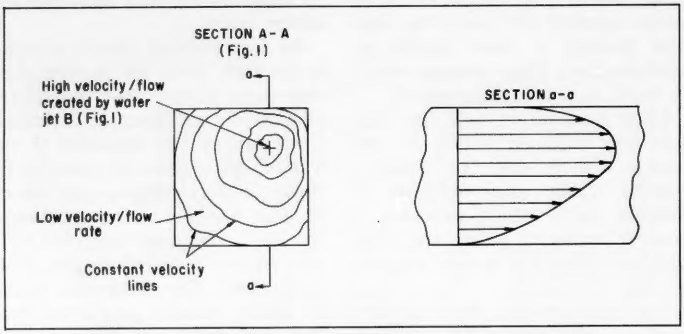

Figure 5.—Velocity profile in singulation duct at entrance.

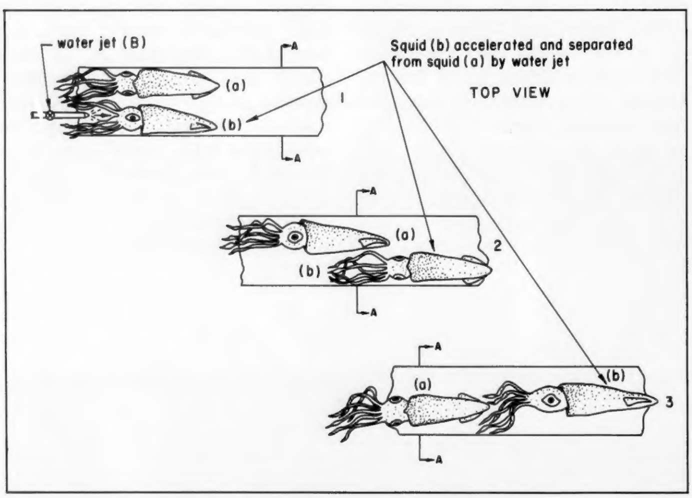

Figure 6.—Squid separated in singulation duct.

H within 3 minutes. Similarly the placement of water jet G insures that all squid are diverted from duct H to duct I.

Performance Investigation

The singulation rate for removing squid from the tank depends on squid density. Three tests were performed to gauge the effect of tank density on removal rate. Frozen, whole squid, *L. opalescens,* were purchased from Meredith Fish Company[3], Sacramento, Calif., and thawed just prior to use. Their overall lengths, from mantle tip to tentacle end, ranged from 23 to 33 cm (9-13 inches). For the first test the number of squid in the tank was maintained at 10 for a 10-minute test period. The number of squid removed and ducted from the tank to water jet removal station G (Fig. 1) were counted. The density of the squid in the tank was then changed to 30 and 60 squid for 10-minute periods.

The 10-minute test period was chosen because the condition of the squid deteriorates if exposed to fresh water and repeated action of the water jets for a greater period. The mucous-like layer covering the squid disintegrates. In actual practice this would not be a problem as the squid would be continuously removed from the system and skinned or packaged. In the above tests the squid were recycled many times.

A second series of tests was performed to test the effectiveness of the water jet removal device and alignment system. Two modes of operation were tested. Continuous operation would simulate the singulation of squid for a packing operation of whole squid. Removal of squid from the ducting system on demand would provide singulated squid for a cleaning machine.

In a continuous operation mode, water jet G (Fig. 1) was fixed in the open position. All squid were to be diverted out of the ducting system onto the alignment slide. The number of squid in the tank was maintained at 60 and the duration of the test was again 10 minutes. The squid arriving at the bottom of the slide in the desired condition for packaging in uniform alignment were counted. All squid were returned to the circulating tank, thus maintaining 60 squid in the tank. The water deposited on the slide with the squid was also recycled by pumping it back into the singulation tank continuously.

In tests simulating the demands for aligned squid of the skinning and gutting machine described earlier, squid were removed from the ducting system every 8 seconds. The electric eye controlling water jet G was equipped with a reset circuit which prevented its operation until a simulated signal from the squid cleaning machine was received. The

[3]Mention of trade names, products, or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

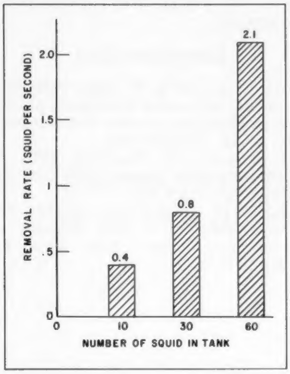

Figure 7.—Average singulation rate of squid ducted out of the holding tank.

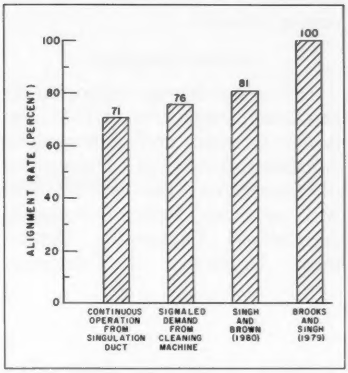

Figure 8.—Alignment rate for squid sliding on inclined ramp.

next squid in the duct then activated the electric eye and the water jet diverted that squid to the alignment slide. The number of squid in the tank was maintained at 60 and duration of the test was 10 minutes. Squid removed from the ducting system and aligned properly were recorded and the squid were returned to the singulation tank.

Results and Discussion

In Figure 7 are shown the results of tests performed to determine the average removal rate over the 10-minute test period for the ducting of squid from the circulation tank. The average removal rates ranged from 0.4 squid/second with a tank density of 10 squid, to 0.8 squid/second for 30 squid, and 2.1 squid/second for 60 squid. For the 60-squid test, the spacing of the squid in the duct dropped to an average of only 25 cm. This is about the minimum spacing required for effective removal of squid from the duct by water jet G (Fig. 1).

The percentage of squid removed from the ducting by water jet G under continuous operating conditions was at the 92 percent level. With a tank density of 60 squid, 1.9 squid/second on the average were successfully diverted to the alignment slide under continuous operation. These squid were aligned at a 71 percent level (Fig. 8). This is lower than the 81 percent level reported by Singh and Brown (1980), and the 100 percent figure reported by Brooks and Singh (1979). The reasons for this low alignment rate will be discussed later.

As noted, 12-15 workers currently pack squid in 2.2 kg boxes, with the top layer aligned, at the rate of 56.7 kg/minute. Using an average of 13.0 squid/kg, 12 workers could pack 740 squid/minute. Each worker packs on the average 1 squid/second. The singulation/alignment technique described in this report could supply a worker with 1.9 squid/second if the 100 percent alignment rate can be achieved.

The second test for removal of squid from the ducting on simulated demand from the squid cleaning machine resulted in an 89 percent removal rate. Every 8 seconds the electric eye was reset with a simulated signal from the skinning/cleaning machine. The first squid passing the electric eye activated the water jet G removal system (Fig. 1). The squid not removed by this system remained in the duct and returned to the circulation tank. Those squid that were deposited on the alignment slide were aligned at a rate of 76 percent (Fig. 8).

Because the skinning machine developed has an operation time of 8 seconds/squid, the singulation machine could provide squid to a large number of skinning machines. Multiple solenoid-controlled water jets diverting squid would be required. With a maximum removal rate from the singulation tank of 2.1 squid/second, this singulation device could automatically feed 15-17 squid skinning machines.

These squid removed from the ducting system and deposited on the alignment slide were aligned at a lower than expected rate. Figure 8 compares these results with previous research. Singh and Brown (1980) reported an alignment rate of 81 percent for squid deposited on the alignment slide of the squid cleaning machine described. In a public demonstration of the squid cleaning machine on 19 April 1980, a near 100 percent alignment rate was observed. The sample size was 150 squid. Brooks and Singh (1979) found a 100 percent alignment rate for squid dropped on an alignment ramp. Operated continuously the alignment slide in this report aligned squid at a 71 percent rate. On simulated demand, a 76 percent rate was achieved (Fig. 8). The two most likely reasons for the difference in performance are: 1) The quantity of water dropped on the slide with the squid; and 2) the material that the slide is made of. Brooks and Singh (1979) observed squid orientation on a galvanized sheet-metal ramp with a constant fine spray of water to facilitate the sliding motion. The squid cleaning machine developed by Singh and Brown (1980) used a Plexiglas slide and fine water spray to orient squid. Large amounts of water are deposited along with the squid by the system described in this report. PVC

plastic was used in the construction of the slide.

A mechanical device to separate the squid from excess water and then drop the squid on the slide is needed to improve the alignment rate. An investigation of the slide material and its effect on the friction coefficient of squid tentacles and body would be necessary to select the optimum material for this component of the system. Stainless steel would be preferred by the processing industry.

Acknowledgment

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Shrimp 1980: Consumption Is Up in a Difficult Year

The U.S. shrimp industry experienced a very difficult year in 1980. The recession in the United States dampened demand for shrimp and prices fell, while operating costs rose sharply as fuel prices and interest rates hit record levels.

Shrimp stocks were high in the first 7 months. Imports were reduced, but landings were up slightly above 1979 after a slow start. Despite the difficulties in 1980, consumption increased 10 percent over 1979, according to preliminary data.

Prices of shrimp at the ex-vessel and wholesale levels had moved strongly upward from December 1977 to June 1979, and then moved downward through November and December 1980, respectively. Ex-vessel prices rose from $2.22 per pound in December 1977, then fell from a peak of $5.00 in June 1979 to $3.03 in November 1980, and increased to $3.36 in January 1981 for western Gulf shrimp, 31-35 per pound heads off.

Shrimp landings in the Gulf and South Atlantic increased 4 percent to 152 million pounds (heads off). Total U.S. landings advanced 1 percent to 208 million pounds but were 15 percent below the 1974-78 average (Table 1). The larger catch of small size southern shrimp improved supplies for canning. The Gulf canned pack, normally over half the U.S. total, was 1.8 million standard cases, double the low 1979 pack, but only 3 percent above the 1974-78 average.

The slight increase in landings was offset by the 4 percent drop in imports to 256 million pounds (heads off), about the same as the 1974-78 average. Although total imports were down, imports of raw headless shrimp rose to 139 million pounds in 1980, up 12 percent from 1979. Imports of peeled raw shrimp fell 23 percent, mostly because of the sharp drop in shipments from India, the leading supplier in 1979. Total imports from Mexico increased to 76 million pounds, up 6 percent from 1979. Total imports from Ecuador, the second leading U.S. supplier in 1980, were 20 million pounds, 47 percent above 1979.

Cold storage holdings of shrimp at the start of 1980 were high, 14 percent above the 1974-78 average. Weak demand, associated with slowness in the economy, and the high cost of carrying inventories prompted price reductions in an effort to reduce inventories. They were above 1979 levels until 1 August, but then fell and remained below 1979 levels for the rest of the year. At the end of 1980, holdings were down 21 percent from a year earlier to 62 million pounds (heads off).

Total supplies of shrimp were 3 percent higher in 1980 than in 1979, but 5 percent below the 1974-78 average. High beginning inventories, along with the slight increase in landings easily offset the drop in imports. Increased supplies went to consumption, not to an inventory build-up late in the year as in 1979, nor to exports, which dropped substantially below both year-earlier and 1974-78 average levels. Most of the increase in consumption occurred in the fourth quarter, consumption in the second and third quarters being below a year earlier. Lower prices helped spur the 10 percent increase in consumption to 440 million pounds (heads off), although consumption was still 2 percent below the 1974-78 average.

The outlook for the demand for shrimp appears to be improving. Though prices were fairly low at the wholesale level, they may have bottomed out in late 1980; prices have increased slightly in early 1981. The strength of the recovery will depend substantially on the growth in the U.S. economy and the size of expected increases in real disposable income. Inventories are below the 1974-78 average. Prices of meat and poultry are expected to increase from 15 to 17 percent (sales adjusted for inflation) compared with a 1.6 percent decline in 1980. (Source: *Fishery Market News*.)

Table 1.—Supplies and uses of all shrimp, 1974-78 average, 1979, and 1980, heads off weight. Data are preliminary.

Item	Million pounds 1974-78 avg.	1979	1980
Supplies			
Beginning stocks	68.8	56.2	78.3
Landings	245.0	205.6	208.3
Imports	255.7	267.1	256.0
Total	569.5	528.9	542.6
Uses			
Ending stocks	64.2	78.3	62.1
Exports			
Fresh and frozen	33.0	34.1	18.8
Canned	14.5	11.0	11.8
Foreign shrimp	8.9	5.8	9.6
Apparent consumption	448.9	399.7	440.3

NOAA COMPONENTS WIN UNIT AWARDS

At the annual NOAA awards ceremony held 5 December 1980, 24 of-

fices, including six NMFS groups, received unit citations for commendable performances and outstanding contributions during the past year. The NMFS units included the following:

The Financial Services Division, Washington D.C.; Financial Assistance Branch, Northeast Region; Financial Services Branch, Southeast Region; Financial Services Office, Northwest Region; and the Financial Services Office, Southwest Region, for administering five active programs of varied financial services for the fishing industry and performing residual administrative duties for two inactive programs.

The NMFS Plan Review Program was recognized for outstanding performance in meeting its responsibilities under the FCMA.

The NMFS Southeast Region's Law Enforcement Division was cited for a commendable job in meeting its responsibilities with limited resources through an innovative approach to solving enforcement problems.

The NMFS Southeast Regional Environmental Assessment Branch was acclaimed for exemplary implementation of contracting permit application reviews in the Southeast Region. Recognized were the Regional Office, Beaufort Field Office, Panama City Field Office, and the Galveston Field Office.

The NMFS' Harvesting Technology Sea Turtle Excluder Trawl Project was cited for its outstanding collective efforts toward furthering management capabilities of the Service.

And, the NMFS Enforcement Division was recognized for producing an Enforcement Operations Manual which is a vital step in efforts to manage and increase the productivity of enforcement activities.

National Weather Units cited include: Techniques Development Laboratory for an outstanding level of productivity and scientific research and development; WSO Pensacola, Fla., for exemplary performance in the face of Hurricane Frederic, September 1979; WSO Mobile, Ala., for exemplary performance in the face of Hurricane Frederic, September 1979; WSO Evansville, Ind., for superb performance during the disastrous 26 July flash flooding in southern Indiana; WSO Klamath Falls, Oreg., for general weather services and specialized agricultural services to southcentral Oregon and northeastern California; WSO Bethel, Alaska, for its outstanding performance and accomplishments in observations which has given it an excellent rating in the Alaska region; NWS Pacific Region, Regional Substation Management Section, for outstanding contribution and achievement in three NOAA/NWS programs; NWS Facilities Engineering Branch, for outstanding performance in the preparation of sites for installation of equipment for the AFOS Program; and the NWS Jacksonville Center, Weather Service Unit, for outstanding support provided to the FAA's Jacksonville, Fla., Air Route Traffic Control Center during 1978 and 1979.

Environmental Research Laboratory units cited include: Research Facilities Center for outstanding performance in logging over 2,300 flight hours in support of a multitude of national and international programs; Users' Network of Applied Models for Air Pollution for its contributions to the creation and implementation of UNAMAP; Space Environment Services Center for unusual dedication and ingenuity in greatly advancing and improving the NOAA/ERL program of solar-terrestrial services; Boulder Atmospheric Observatory for outstanding performance in bringing the BAO tower into operation and planning and formulating the BAO scientific program; and the Real Time Data Group for unusual dedication and ingenuity in obtaining parts and software to collect, process, and display data from SELDADS.

Other NOAA units cited include: CZM, Marine Sanctuaries Operations and Enforcement Staff, for its individual and collective efforts in management of NOAA's marine sanctuaries; NOS, NOAA Ship *Researcher,* for outstanding contribution to the scientific field during 1979; NOS, New Datum Section, for outstanding performance and accomplishments during the transition period from one computer for another in transferring 3,100 horizontal adjustment sets of data; and RD, Outer Continental Shelf Environmental Assessment Program, for the development of a program of multidisciplinary scientific research which meets the environmental information needs of decision-makers responsible for leasing the Alaska OCS for oil and gas development.

Satellite Data Aid Alaskan Fishermen

A polar-orbiting satellite is proving a financial windfall for some Alaskan fishermen and other ocean-related enterprises. The Commerce Department's National Oceanic and Atmospheric Administration (NOAA) reports satellite data on sea temperatures and ice conditions have saved one Alaskan herring processing plant $8,000 daily in wages and fuel costs.

The data, turned into temperature charts, indicate exactly where the company should send its floating processing plant for herring runs. The runs occur in spring in areas where surface temperatures have warmed to 4°C.

NOAA began distributing charts on an experimental basis about a year ago. It now sends them to more than 100 users, ranging from the U.S. Coast Guard to oil exploration companies. The charts are prepared from imagery taken by the National Earth Satellite Services' NOAA-6 satellite which makes two passes

over Alaskan waters every 24 hours. As it does, sensing devices aboard the craft detect heat and, during daylight, reflected light from the sea surface. The satellite imagery is then converted into varying shades of grey representing specific temperatures.

Users of the charts receive them weekly by telecopier, facsimile, mail, or special messenger. Among users are king crab fishermen in the southern Bering Sea and Bristol Bay. A year ago, they lost more than $3 million in pots because of ice formation. The fishermen now monitor the charts to determine when to retrieve their pots before ice forms.

Compensation Changes Set for Commercial Fishermen

The Commerce Department's National Oceanic and Atmospheric Administration (NOAA) will compensate fishermen for some income lost because of damage or destruction of their gear by another ship, but will no longer reimburse them for losses caused by nature.

Amendments to the American Fisheries Promotion Act, signed 22 December, permit the compensation of up to 25 percent of gross income lost by a fisherman because fishing was curtailed or impaired by an accident with another vessel. The amendments, however, no longer permit reimbursements for losses due to "acts of God."

All claims will be presumed to have been caused by another vessel unless the facts show otherwise. A loss that clearly can be attributed to a hurricane that occurred at the same time and place will be denied.

Before the change in the law, nearly 600 claims were honored for damage caused by hurricanes David and Allen and the Bering Sea ice floe during early 1980. All such claims submitted before 22 December will still be processed. Under the amendment, casualties occurring between 17 September 1978 and 22 December 1980, not previously filed on time, could have been until 19 February 1981.

Fishermen also may be reimbursed for any reasonable deductible from their insurance coverage for losses or damage caused by a foreign vessel. Since October 1978, more than $4 million has been paid fishermen under the Fishing Vessel and Gear Damage Compensation Fund. For additional information contact the Financial Services Division, National Marine Fisheries Service, NOAA, Washington, DC 20235.

Bering Sea Fish Resource Charts Now Are Available

In May through July 1980, an extensive, demersal crab-groundfish resource survey was conducted in the eastern Bering Sea by the NMFS Northwest and Alaska Fisheries Center. The results of this survey are now available as data sheets representing the catch in pounds per hour trawled. The sheets are scaled to overlay National Ocean Survey Chart 16006.

The data sheets provide a comprehensive picture of the distribution and relative abundance of each resource within the area lat. 54-61°N, long. 156-176°W. All persons in the fishing industry who have use for this information are invited to submit requests for the following charts: Total groundfish, walleye pollock, Pacific cod, yellowfin sole, Pacific halibut, total flounder, total rockfish, red king crab, blue king crab, Tanner crab (*C. bairdi*), Tanner crab (*C. opilio*), Korean horsehair crab, total snails, total cephalopods, and pollock average lengths.

Mail requests to: Bering Sea Project, Resource Assessment Division, Northwest and Alaska Fisheries Center, NMFS, NOAA, 2725 Montlake Blvd. East, Seattle, WA 98112.

Taggart Sworn in as NOAA Corps Director

Rear Admiral Kelly E. Taggart, is now director of the National Oceanic and Atmospheric Administration's (NOAA) Corps, one of the nation's seven uniformed services. Sworn in by former Commerce Secretary Philip M. Klutznick on 8 January, Taggart succeeded retiring Rear Admiral Harley D. Nygren.

The 400 corps officers provide scientific and engineering services for NOAA, the civil sea and air agency that predicts the weather and protects the oceans and coastline.

Taggart, 48, formerly was deputy associate director of the National Ocean Survey's (NOS) Office of Fleet Operations. A 25-year veteran of government service, he has served with various Commerce Department agencies since joining the Coast and Geodetic Survey in 1955. Taggart has served on five of NOAA's 25 vessels, including a tour as Commanding Officer of *Oceanographer,* Flagship of the NOAA fleet.

NOAA Awards Presented for Outstanding Service

Awards went to 11 employees of the National Oceanic and Atmospheric Administration at ceremonies in Washington, D.C., on 5 December, including two National Marine Fisheries Service employees, Edna H. Ross and Phyllis J. Fisher. The awards ranged from $1,000 to $5,000 for outstanding service to the Commerce Department agency over the past year.

The winners were: Thomas D. Potter, director of NOAA's Environmental Data and Information Service, and Edna H. Ross, National Marine Fisheries Service, $1,000 each for outstanding contributions to the agency's Equal Employment Opportunity Program; J. Murray Mitchell, Jr., Environmental Data and Information Service, Washington, D.C., $5,000 for

outstanding achievement in the science of climatic variability; Anthony J. L. Tafoya, Environmental Research Laboratories, Boulder, Colo., $1,000 for outstanding service to the Hispanic community and to NOAA's Hispanic program; Robert H. Stockman, NOAA Office of Policy and Planning in Washington, D.C., $1,000 for outstanding policy guidance in marine sciences; Kenneth G. Vadnais, NOAA Corps in Washington, D.C., $1,000 for outstanding contributions to the development of an airborne gamma radiation snow survey system; Kathryn L. Cousins, NOAA Office of Coastal Zone Management in Washington, D.C., $2,000 for outstanding achievement in the development of Coastal Zone Management programs from Maine to New Jersey; Phyllis J. Fisher, National Marine Fisheries Service, Miami, Fla., $2,000 for outstanding achievement in administration; Charles R. Dinkel, National Ocean Survey in Washington, D.C., $3,000 for outstanding achievement in systems innovation for bathymetric research; Syukuro Manabe, Environmental Research Laboratories in Princeton, N.J., $3,000 for outstanding achievement in the science of climate dynamics; and John T. Murray, National Weather Service, Williamsport, Pa., $1,000 for outstanding achievement in community preparedness programs.

Pomfret Eyed as a Potential Food Source

The Utilization Research Divison laboratory of the NMFS Northwest and Alaska Fisheries Center, Seattle, Wash., received several hundred pounds of whole pomfret, *Brama japonica,* for use in utilization studies and trace metal composition analyses. The fish were caught in July 1980 with gill nets by the Japanese research vessel *Oshoro Maru* in the Gulf of Alaska. Personnel from the National Marine Mammal Laboratory, acting as observers aboard the vessel, obtained and shipped the samples to Seattle.

Pomfret is an epipelagic fish that occurs abundantly but erratically offshore from Mexico to the Gulf of Alaska and the Aleutian Islands, but is not common in the Bering Sea. Although considered a highly edible species, little information is available about their use because pomfret occur seasonally and erratically. They are principally fished by foreign vessels on the high seas. Because of their potential as an underutilized species for development, we have begun, on an "as available" basis, preliminary work to characterize the fish as a food product.

In the laboratory, the pomfret were subjected to chemical and sensory analyses. The fish were measured (39.3 ± 2.2 cm), weighed ($1,131 \pm 176$ g), and filleted to determine yield (42.7 ± 3.4 percent). For canned products, fillets were smoked or steamed and combined with salt, vegetable oil, onion broth, or chicken broth. Five panelists rated the canned products in order of preference and by flavor and texture (5-point scale).

All products were found acceptable but fish smoked with oil added was the most preferred and the steamed fish with onion broth and salt added was least accepted. The steamed samples were analyzed for overall preference (9-point scale) by 13 panelists. Scores ranged from 4 to 9 and averaged 7.2 ± 1.3 denoting moderate to high acceptability.

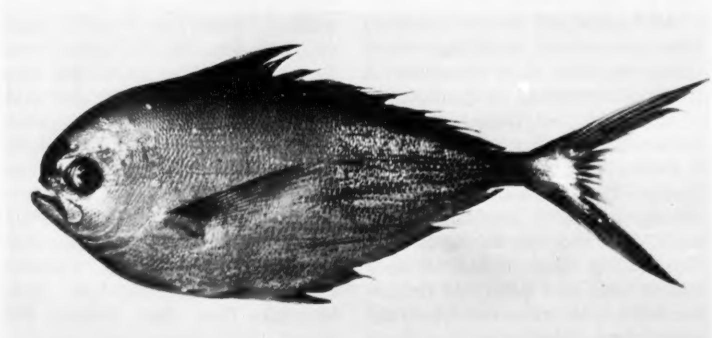
Fillets from 13 pomfret were then analyzed for chemical proximate composition. The following values are the means, standard deviations, and ranges of these analyses in g/100 g.

Item	Moisture	Protein	Fats & oils	Ash
Mean	74.2	22.2	2.3	1.3
S.D.	± 1.3	± 0.8	± 1.3	± 0.2
Range	76.2-81.6	20.6-24.2	0.6-5.0	1.0-2.1

In addition, muscle samples from the 24 fish were analyzed for 25 minerals and trace elements using plasma emission spectroscopy.

Based on these analyses, pomfret are high in protein and fairly low but variable in fat content. They have a mineral and trace element composition typical of other fish such as Pacific cod, *Gadus macrocephalus*. The analyses showed no significant levels of elements of public health concern, such as mercury and lead. Analyses of pomfret taken in other areas or seasons may vary in composition; therefore the studies will continue when additional samples become available.

Harold Barnett and *Fuad Teeny*



Japanese Shrimp Import Trends for 1963-80 Told

Japanese imports of frozen shrimp in 1980 amounted to 143,256 metric tons (t), valued at ¥240,353 million ($1,073 million at ¥224=US$1), down 10 percent in quantity and 22 percent in value compared with 1979. This was the first decline in shrimp imports since 1974 and the lowest imports in the past 3 years. The decline was reportedly due to the rise in storage holdings and depressed domestic sales. The import prices averaged ¥1,677/kg ($3.40/pound) for the year, a 12 percent decrease from 1979.

However, frozen shrimp imports into Japan for the month of December 1980 were 14,893 t valued at ¥22,496 million ($107 million at ¥210=US$1) on a customs clearance basis, according to the Finance Ministry. This is 2,361 t or 18 percent above the December 1979 imports of 12,532 t. The high level of imports in December was attributed primarily to large purchases from India (3,629 t), Indonesia (1,979 t), and the People's Republic of China (PRC) (1,417 t), which together accounted for 47 percent of the total. Other large suppliers were Australia (850 t), Taiwan (797 t), Thailand (781 t), Pakistan (703 t), Hong Kong (648 t), Norway (589 t), Mexico (576 t), Canada (303 t), Sabah (299 t), and Burma (264 t). Imports from the United States were 33 t.

Since Japan liberalized its shrimp imports in 1961, overseas purchases rose steadily save for brief lapses in 1968, 1974, and 1980. Shrimp imports in 1980 rose more than

Japan's frozen shrimp imports, by leading countries, 1963-80.

Year	Total imports: t	Total imports: US$1,000	Leading country (t): India	Indonesia	PRC	Mexico	Year	Total imports: t	Total imports: US$1,000	Leading country (t): India	Indonesia	PRC	Mexico
1963	11,708	$23,475	n.a.[1]	n.a.	n.a.	n.a.	1972	88,120	$ 291,943	12,812	13,824	3,519	5,407
1964	18,167	31,437	n.a.	n.a.	n.a.	n.a.	1973	117,474	429,845	21,903	18,764	4,475	8,839
1965	21,011	35,938	851	n.a.	5,875	5,210	1974	103,311	404,024	19,898	19,385	9,483	4,580
1966	36,156	60,085	993	n.a.	11,769	4,889	1975	113,672	464,527	29,942	21,060	9,768	4,085
1967	44,466	79,732	2,147	15	5,004	7,995	1976	123,334	738,986	26,901	25,510	5,569	5,235
1968	35,204	78,079	3,164	661	3,769	5,769	1977	124,780	790,806	25,803	25,701	3,749	4,184
1969	48,886	121,748	4,864	22,604	4,136	5,511	1978	143,962	998,581	31,580	28,338	9,197	7,860
1970	57,146	137,026	6,210	3,684	6,248	7,210	1979	158,672	1,375,210	38,757	29,621	12,082	4,727
1971	78,874	214,591	9,702	8,223	4,990	6,520	1980	143,256	1,073,004	35,249	27,569	14,502	3,399

[1]n.a. = not available.

Japanese frozen shrimp imports, by country of origin, 1974-80.

Country of origin	1974	1975	1976	1977	1978	1979	1980	Country of origin	1974	1975	1976	1977	1978	1979	1980
India	19,898	29,942	26,901	25,803	31,580	38,757	35,249	Philippines	1,521	1,109	2,081	2,393	2,791	3,701	2,395
Indonesia	19,385	21,060	25,510	25,701	28,338	29,621	27,569	Nigeria	771	867	831	1,060	1,060	564	530
PRC	9,483	9,768	5,569	3,749	9,197	12,082	14,502	Sabah	1,728	1,515	2,296	2,505	2,328	2,728	2,412
Mexico	4,580	4,085	5,235	4,184	7,860	4,727	3,399	Bahrain	1,227	1,014	974	1,041	1,031	239	—
Thailand	6,314	8,837	9,849	2,760	8,377	9,294	8,850	Brazil	855	391	770	1,595	2,597	2,921	2,732
Taiwan	3,245	3,395	3,241	4,389	5,567	5,998	4,990	Liberia	611	330	320	270	212	181	122
Pakistan	2,305	2,951	3,892	3,889	3,675	4,179	3,575	Guyana	762	939	900	1,067	1,176	875	976
S. Korea	3,127	2,932	4,673	2,574	2,461	2,219	2,501	Cameroons	809	474	386	217	88	170	10
Malaysia	2,619	2,392	3,877	3,392	2,827	3,131	1,717	Singapore	517	345	336	489	374	326	124
Iran	854	651	803	515	815	996	342	U.S.A.	130	68	332	454	479	285	68
Australia	5,189	4,663	6,189	7,742	7,546	10,955	8,053	Bangladesh	220	339	565	865	1,170	1,694	1,721
Hong Kong	4,051	4,140	4,627	5,993	4,608	4,365	3,685	U.S.S.R.	1,294	0	0	0	1,861	261	121
Cuba	3,193	3,548	1,693	1,417	919	1,125	592								
Kuwait	236	379	1,031	572	635	485	175	Other Total	103,311	113,672	123,334	124,780	143,962	158,672	143,256
Vietnam	2,154	1,639	2,356	2,760	2,411	1,794	1,666								

twelvefold over 1963. Annual imports in excess of 100,000 t have been maintained since 1973. Up to 1970, Mexico and the PRC were major suppliers of shrimp to Japan. Since 1971, however, India and Indonesia have replaced them as leading suppliers and accounted for 44 percent of Japan's total shrimp imports in 1980. The PRC was the third and Mexico the ninth major suppliers in 1980, each with 14,502 t and 3,399 t, respectively.

Other important suppliers in 1980 were Thailand with 8,850 t, Australia with 8,053 t, Taiwan with 4,990 t, Hong Kong with 3,685 t, Pakistan with 3,575 t, Brazil with 2,732 t, and South Korea with 2,501 t. Imports for the year were record highs from the PRC and Bangladesh. Imports from the United States were 68 t. (Source: FFIR 81-4.)

Japan's 1979 Marine Fish Catch Drops 2%

The Japanese marine fisheries catch from January through December 1979 totaled 9,476,793 metric tons (t), down 2 percent from 1978, according to the Ministry of Agriculture, Forestry, and Fisheries. Sharp declines occurred in some species, notably dolphin fish (-30 percent), albacore (-24 percent), and saury (-23 percent), whereas significant gains were recorded in the catches of king crab (+108 percent), salmon (+28 percent), and rockfish (+25 percent).

The most important species landed in terms of quantity was sardine, as in 1978, with a catch of 1,979,417 t, which was followed by Alaska pollock with 1,551,116 t. Mackerel, the second important species in quantity in 1978, declined 8 percent in 1979 and came in third. Sardine, Alaska pollock, and mackerel together accounted for 53 percent of the total marine catch for 1979.

Tuna and skipjack landings, which totaled 709,435 t in 1979 were down 8 percent due largely to the sharp decline in the catches of albacore (-24 percent) and skipjack tuna (-10 percent). (Source: FFIR 81-1.)

Japan's catch of selected marine species, 1978 and 1979.

	Catch (t)	
Species	1979	1978
Tuna		
Bluefin	44,241	46,555
Albacore	66,822	87,675
Bigeye	130,466	127,666
Yellowfin, large	99,659	97,983
Yellowfin, small	21,729	24,712
Total	362,917	384,591
Skipjack		
Skipjack	329,948	369,530
Frigate mackerel	15,570	15,091
Total	346,518	384,621
Billfish	43,357	46,627
Shark	42,480	41,775
Salmon	131,021	102,760
Herring	6,819	6,708
Sardine	1,979,517	1,881,575
Jack mackerel	183,883	153,131
Mackerel	1,491,051	1,625,865
Saury	277,960	360,213
Yellowtail	44,970	37,414

	Catch (t)	
Species	1979	1978
Flatfish	288,896	313,830
Cod		
Cod	91,829	89,016
Alaska pollock	1,551.116	1,546,176
Total	1,642,945	1,635,192
Atka mackerel	118,888	134,763
Rockfish	40,447	32,239
Rockcod	9,927	11,733
Sandfish	10,179	12,551
Argentine	12,088	13,103
Croaker	39,444	37,465
Lizard-fish	21,576	20,967
Marine eel	15,768	17,736
Hairtail	30,518	28,085
Sea-robin	2,473	2,761
Ray	9,496	8,264
Sea bream	28,825	30,065
Dolphin fish	9,470	13,467
Flying fish	8,761	9,555
Mullet	11,651	10,652

	Catch (t)	
Species	1979	1978
Seabass	9,544	11,570
Sandlance	110,484	99,078
Shrimp	52,661	59,676
Crab		
King	270	130
Tanner	23,476	22,985
Blue	3,905	3,500
Other	52,618	53,827
Total	80,269	80,442
Squid		
Common squid	212,849	257,117
Cuttlefish	14,148	18,772
Other squid	301,837	243,824
Total	528,831	519,713
Octopus	51,986	65,441
Sea urchin	26,500	25,930
Sea cucumber	9,381	10,143
Shellfish	357,490	347,190
Seaweeds	186,494	162,893

Russians Culture Caspian Inconnu

Soviet researchers at the Caspian Scientific Research Institute of Fisheries have reported that the Caspian inconnu, *Stenodus leucichthys leucichthys*, can be spawned in captivity. The cultivation of these fish is being conducted by three plants in the Volga River delta, which receive and breed the expensive salmonid fingerlings. An ecological regime for spawning that resembles natural conditions has been created in artificial basins. At the age of 30-35 days, the juvenile fish are released into their permanent habitat in the Caspian Sea.
(Source: LSD 80-19.)

Mexico Develops Sea Urchin Fishery

Mexico has developed a small sea urchin fishery. Commercial fishing began in 1972; earlier Mexican cooperative abalone fishermen used to destroy sea urchins by spreading quicklime along the coast where they occurred. Sea urchins compete with abalone for seaweed and kelp and as a result were disliked by the abalone fishermen. Mexican fishery officials encouraged the cooperative fishermen to harvest the sea urchins along with abalone and by 1972 commercial exports began.

Species

Two species of sea urchin are commonly fished in Mexican waters: Purple sea urchin, *Strongylocentrotus purpuratus*, and red sea urchin, *S. franciscanus*. The purple sea urchin lives on rocky bottoms in water up to 65 m deep, where the species survives in temperatures ranging from 2° to 23° C. The red sea urchin typically lives at depths from 5 to 10 m, although it is sometimes found at depths of up to 125 m.

Sea urchins feed on seaweed, dead animals, and even microorganisms found in sand and sewage, but they prefer seaweed and kelp. They are often destroyed (outside the Orient) by fishermen as pests because they can destroy kelp and seaweed beds. Sea urchin populations can reportedly survive in the same area even after they have eaten all of the seaweed growing there by surviving on algae.

The gonads are the only edible part of the sea urchin. Each sea urchin has five gonads which are commonly referred to as "roe" and are very nutritional. The quality (color and firmness) of the roe has been found to depend primarily on the sea urchin's diet, and will reportedly only be of marketable quality if seaweed formed the bulk of its diet. Predators of the sea urchin include rockfish, flatfish, lobsters, crabs, sea gulls, and sea otters.

Seasons and Grounds

Mexico's sea urchin harvest season runs from June to December. Sea urchins are available all year but in the June to December period the roe has a firmer consistency. Red and purple sea urchins occur in commercial quantities along the northern coast of the Baja Peninsula, from Cedros Island north to the U.S. border (see map). Mexico's Baja Peninsula is the southern limit of the range of both purple and red sea urchins, but their northern range extends to Alaska. Off the northern Baja Peninsula there tend to be large groups of sea urchins wherever the seaweed *Macrocystis pyrifera* occurs.

Fishing Methods

Sea urchins are harvested by both Mexican cooperative and private fishermen aided by Japanese who employ sophisticated diving equipment such as undersea television cameras and photographic equipment which record sea urchin populations for future reference. Mexican fishermen, however, usually rely on small launches and simple diving equipment. Usually at least three Mexican fishermen work together: The diver who collects the sea urchin, a person who is in charge of extracting the roe, and a person who is in charge of the equipment.

Catch

Commercial sea urchin fishing began in 1972 and the catch has since increased from an initial 13 metric tons (t) to 260 t in 1978, the latest date for which data are available. Sea urchins are landed at many scattered locations along the coast of Baja California Norte, but the largest quantities are landed near Ensenada and Rosario (Table 1).

Two major Japanese companies have signed agreements with the Mexican Government to export Mexican sea urchins to Japan. The Taiyo Fisheries Company[1] ships the product to Sapporo. The Sato Shoten Company ships them to Tokyo. Both Japanese companies have been operating in Mexico since 1973. Available information on these ventures is contradictory, but apparently the Japanese companies have formed two Mexican joint venture companies, EPEM (Empresa Promotora y Exportadora de Mariscos) and PROTAKSA (expansion unknown). With an initial investment of $150,000, EPEM built processing plants in Rosario and in Ensenada where about 70 workers clean and pack the roe.

Processing

Processing sea urchin is a delicate and arduous procedure. First-grade sea urchin roe must be unbroken and the natural surface of the roe retained unruptured. When the sea urchin is cracked open, pieces of spine or shell can easily fall into and break the roe. The roe is carefully cleaned and graded according to texture and color. The best quality roe is an intense yellow and is usually rinsed in a solution of salt and iodine, soaked in a chemical solution, and then frozen to maintain its delicate flavor and texture. It is drained and packed in wooden boxes and air shipped in refrigerated compart-

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Table 1. — Areas and quantity (t) of sea urchins landed in Baja California Norte in 1978.

Area	Quantity
Tijuana	6.9
Ensenada	158.0
San Quitin	1.5
Rosario	89.5
Total	255.9

Source: Direccion de Pesca del Estado de Baja California Norte, 1979.

Table 2. — Quantity[1] and value[2] of Japanese imports of Mexican sea urchin roe from 1973 to July 1980.

Year	Quantity	Value	Year	Quantity	Value
1973	27.0	NA[3]	1977	35.8	375.1
1974	47.8	414.2	1978	44.6	573.0
1975	53.9	493.3	1979	25.7	339.0
1976	82.2	780.8	1980[4]	3.0	38.7

[1]In metric tons.
[2]In US$1,000.
[3]NA = Not available.
[4]Through July.
Source: Japanese Marine Products Importer's Association, "Imports of marine products by country," 1973-July 1980.

ments to Japan. Some sea urchin roe is also dried and salted but usually only low-quality roe, as the frozen roe commands a much higher price.

Exports to Japan

Almost all of Mexico's sea urchin is exported to Japan where it is considered a luxury food. Japanese imports of Mexican sea urchin have been erratic during the period from 1973 to 1980. Exports to Japan increased rapidly from 27 t (product weight) in 1973 to a record 82 t in 1976. Since then exports have declined to only 26 t in 1979 (Table 2). The reason for these variations is not known.

Sea urchin roe in Japan is only available to Japanese consumers through restaurants and is not found in fish markets. Sea urchin roe is most commonly sold in Japanese "sushi" bars. Sushi is a Japanese food formed from rice seasoned with sugar, salt, and rice vinegar. Raw seafood, such as sea urchin roe, is often served on or with a rice-shaped cake. (Source: IFR-80/169.)

Note: Unless otherwise credited, material in this section is from either the Foreign Fishery Information Releases (FFIR), compiled by Sunee C. Sonu, Foreign Reporting Branch, Fishery Development Division, Southwest Region, NMFS, NOAA, Terminal Island, CA 90731, or the International Fishery Releases (IFR), or the Language Services Daily (LSD) or Biweekly (LSB) reports produced by the Office of International Fisheries, NMFS, NOAA, Washington, DC 20235.

Japan Sees Progress in Yellowtail Culture

The development of nursery production and stock techniques in 1980 has greatly enlarged the volume of fish produced by aquaculture in Japan. In particular, the volume of yellowtail hatched in nurseries rose from 100,000 to 300,000. Other increased stocks include flounder, scad, blue crab, and porgy. The target for tiger shrimp nursery production of 78,900,000 is in the process of being accomplished and the porgy target has already been greatly exceeded at 800,000.

Cultured yellowtail production rose from 20,000 t in 1970 to 115,000 t in 1977. However, natural production peaked in 1970 at 55,000 t and declined to 27,000 t in 1977. This trend has been seen in the Seto Inland Sea area, where, between 1968 and 1970, 1,100-1,500 t were caught. However, in 1977 the volume has declined to 400 t. Problems with yellowtail larvae catch and changes in fishing methods were the main factors for the decrease. Since 1977, these resources have again revived, due to the technological development of nursery production.

The Inland Sea production of yellowtail is 500 t to date. It is thought that there are presently enough nurseries to stock yellowtail sufficiently. The large volume in the Inland Sea is mainly due to the fact that this area was used for experimentation during the development of the nursery production techniques.

Furthermore, in fiscal 1979, 25,000 fish reached a record length of 13-20 cm. In the current fiscal year, (April 1980-March 1981) in the eastern part of the Inland Sea, 44,000 nursery-bred fish were caught between 4 and 6 cm, and there was a record catch of 35,000 large nursery-bred fish having a length of 13-20 cm. (Source: LSD 80-24.)

Japan's 1981 Salmon Carryover Stock Down

Data compiled by major Japanese fishery firms show that their frozen, salted, and imported salmon holdings carried over to 1981 totaled 32,100 metric tons (t). This is 51 percent below the carryover of 65,000 t in 1980. Cold-storage holdings of imported salmon declined as much as 65 percent from a year ago. A breakdown of Japanese cold storage holdings of frozen, salted, imported and fall chum salmon as of the beginning of 1980 and 1981 is shown in the table below. (Source: FFIR 81-3.)

Japan's 1981 salmon carryover stocks.

	Salmon holdings (t)					
Item	Reds	Chums	Pinks	Silver	Others	Total
1981						
Frozen	2,000	3,000	100	1,500	1,400	8,000
Imports	6,500	1,000	300	2,000	200	10,000
Salted	2,700	3,200	1,200	1,000	—	8,100
Fall chum	—	6,000	—	—	—	6,000
Total	11,200	13,200	1,600	4,500	1,600	32,100
1980						
Frozen	4,000	13,000	3,300	2,000	—	22,300
Imports	28,000	—	—	—	—	28,000
Salted	3,500	4,100	800	600	—	9,000
Fall chum	—	5,700	—	—	—	5,700
Total	35,500	22,800	4,100	2,600	—	65,000

between relationships determined for each area. For *L. pealei*, differences also exist between sex and among years and seasons. However, comparisons of sums of total observed weight versus sums of total weight, predicted by equations obtained for all data within a given set, indicate that the net results of using a single equation for each species is about as precise as using separate equations for each sex, area, season, and year. These equations are: $W = 0.25662L^{2.15182}$ for *L. pealei* and $W = 0.04810L^{1.71990}$ for *I. illecebrosus*.

New NMFS Scientific Reports Published

The publications listed below may be obtained from either the Superintendent of Documents (address given at end of title paragraph on affected publications) or from D822, User Services Branch, Environmental Science Information Center, NOAA, Rockville, MD 20852. Writing to the agency prior to ordering is advisable to determine availability and price, where appropriate (prices may change and prepayment is required).

NOAA Technical Report NMFS Circular 435. Russo, Joseph L. **"Field guide to fishes commonly taken in longline operations in the western North Atlantic Ocean."** January 1981. 51 p.

ABSTRACT

Keys and species accounts are provided for 43 species of fishes commonly or potentially taken during longline operations in the western North Atlantic Ocean, including the Gulf of Mexico and the Caribbean Sea. The groups of fishes discussed are sharks, lancetfishes, the opah, pomfrets, dolphins, the barracuda, jacks, snake mackerels, tuna and mackerel-like fishes, and billfishes.

NOAA Technical Report NMFS Circular 436. Uchida, Richard N. **"Synopsis of biological data on frigate tuna, *Auxis thazard*, and bullet tuna, *A. rochei*."** January 1981. 63 p.

ABSTRACT

This synopsis of biological and technical data on frigate tuna, *Auxis thazard*, and bullet tuna, *A. rochei*, includes information on identity, distribution, bionomics, life history, population, and exploitation. Over 200 published and unpublished reports, up to and including those published in 1978, are covered.

NOAA Technical Report NMFS SSRF-744. Sund, Paul N. **"Tunas, oceanography and meteorology of the Pacific, an annotated bibliography, 1950-78."** March 1981. 123 p.

ABSTRACT

Annotated references are presented on papers published between 1950 and 1978 about Pacific tunas and about environmental subjects pertaining to tuna distributions and/or ecology. Key words are included and cross-referenced for each citation to aid in selecting specific topics of interest.

NOAA Technical Report NMFS SSRF-745. Lange, Anne M. T., and Karen L. Johnson. **"Dorsal mantle length-total weight relationships of squids *Loligo pealei* and *Illex illecebrosus* from the Atlantic coast of the United States."** March 1981. 17 p.

ABSTRACT

Length-weight data were collected from the Northwest Atlantic, for two commercially important species of squid, *Loligo pealei* and *Illex illecebrosus*, during nine research vessel cruises between 1975 and 1977. These data, in total and by year, sex, season, and area of capture, were fit to length-weight relationships of the form $W=aL^b$. Analyses of covariance indicate that for each species, differences exist

Marine Recreational Symposia Available

Annual marine recreational fisheries symposia, cosponsored for 6 years by the International Game Fish Association, National Coalition for Marine Conservation, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, and the Sport Fishing Institute, have provided a sound record of progress, problems, research, and management in marine recreational fisheries. The fifth of these, **"Marine Recreational Fisheries 5,"** edited by Henry Clepper, could have been titled "Striped Bass: Biology, Fisheries, and Management."

The program was developed around 2 sessions totalling five panels. Panel I, chaired by J. L. McHugh, reviewed the history of striped bass fisheries and harvests on the west coast, the production and harvest of northeast coastal striped bass produced in the Chesapeake Bay, and South Atlantic and Gulf coast striped bass fisheries and research. Panel II, chaired by Hobson Bryant, examined economic aspects of the commercial striped bass harvests, social and economic perspectives on striper anglers and angling, and "other" losses in striped bass stocks, outside fisheries. Panel III, chaired by Daniel Merriman, focused on the biology of the species. Chapters include "Striped bass spawning and egg and larval stages," "Biology of Hudson River

juvenile striped bass," and "Biology of adult striped bass."

Panel IV, Existing Institutions and Management, presented a review of striped bass management, state by state, as well as a discussion of regional management. Panel V, "Legal Framework, Monitoring, Restoration and Implementation," chaired by Christopher Weld, examined environmental quality for striped bass, striped bass management, and artificial propagation and enhancement of the species. Questions and comments from other participants are presented for each panel.

Well written, the chapters provide a good review of the problems and prospects for an important anadromous species. The book is available from the International Game Fish Association, 3000 E. Las Olas Blvd., Ft. Lauderdale, FL 33316 for $15.00.

The previous volume in the series, **"Marine Recreational Fisheries 4,"** also edited by Henry Clepper, provides a wide-ranging examination of the management of marine recreational fisheries and specifically deals with proposed saltwater recreational fishing licenses, a proposal of considerable controversy, in panel presentation and discussions.

Panel I, chaired by John Negroponte, contains three chapters addressing the legal right of anglers to fish and access to fishing waters, a state-federal overview of marine recreational fisheries management, and a discussion of international fisheries management.

Panel II, deals with special problems, including the marine recreational fishing license issue in Florida, coastwide management of marine fisheries, and the conservation and management of highly migratory fishes. Panel III presented discussions of the promise and performance of the Fishery Conservation and Management Act, recreational responsibilities and commercial concerns under the FCMA, and concepts and ecological relationships of underutilized species. Finally, Panel IV explored the controversial marine recreational angling license. Views of anglers, governmental units, and fishery managers were presented as were types of licensing systems and financial issues related to the license. The volume is also available from the IGFA for $15.00.

Colombian Fishery Opportunities Noted

The National Marine Fisheries Service (NMFS) has sponsored a survey of opportunities in Colombia for U.S. fishermen and seafood exporters. A copy of a report on the NMFS mission has been prepared by the U.S. Regional Fisheries Attache for Latin America, Charles Finan. A copy of his 5-page report can be obtained by requesting IFR-80/189, "Colombian Fishery Opportunities, 1980" from your local NMFS Statistics and Market News Office, enclosing a self-addressed and stamped envelope.

In addition, the NMFS Southeastern Regional Office has also prepared a report on the Colombian seafood market. The report contains price information and additional local contacts. A copy can be obtained by requesting "Colombian Market Assessment" from: William Antozzi, Fishery Market Specialist, NMFS, NOAA, Duval Bldg., 9450 Koger Blvd., St. Petersburg, FL 33702. Please enclose a self-addressed mailing label and $0.36 in postage to facilitate handling your request.

Panamanian, Mexican, and Argentinian Fish Reports

The U.S. Embassy in Panama City, Panama, has prepared a 27-page report on the Panamanian fishing industry. The report describes the shrimp fishery, the fish meal industry, artisanal fishing, aquaculture, and the Vacamonte fishing port. It also contains detailed statistical tables and a list of Panamanian Government fisheries agencies, international organizations, fishing industry associations, fishery companies, shipyards, and marine equipment suppliers. A copy of the report can be purchased for $6.50 by ordering report number DIB-81-01-008 from NTIS, Springfield, VA 22161.

Mexican fishermen landed a record 1 million metric tons (t) in 1979. Government officials are still projecting a 2.4 million t catch by 1982. An ambitious fisheries development program is creating trade opportunities for U.S. exporters of vessels, electronic instruments, refrigeration equipment, processing machinery, etc.

The U.S. Regional Fisheries Attache for Latin American, Charles Finan, stationed at the U.S. Embassy in Mexico City, has prepared a 6-page report on the Mexican fishing industry. The report contains information on catch, new vessels, tuna, fish meal, abalone, shrimp, squid, the new National Ports and Fisheries Bank, and Mexico's new nutrition program. A copy of the report can be purchased for $5.00 by ordering report number DIB-80-10-009 from NTIS, Springfield, VA 22161.

Argentina's rapidly growing fishing industry has reportedly experienced a severe financial crisis. The most serious problem is the unfavorable exchange rate maintained by the Government. Argentine companies export 80 to 90 percent of their production and have thus been particularly affected. Company profits began to decline in late 1978 and several companies faced bankruptcy in 1980.

The U.S. Embassy in Buenos Aires has prepared a 7-page report on Argentine fishery developments. A copy can be purchased for $5.00 by ordering report number DIB-80-11-002 from NTIS, Springfield, VA 22161.

Editorial Guidelines for *Marine Fisheries Review*

Marine Fisheries Review publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

Style

In style, *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 6, "A List of Common and Scientific Names of Fishes from the United States and Canada," third edition, 1970. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

Tables and Footnotes

Tables and footnotes should be typed separately and double-spaced. Tables should be numbered and referenced in text. Table headings and format should be consistent; do not use vertical rules.

Literature Citations

Title the list of references "Literature Citations" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, the year and month and volume and issue numbers of the publication. Unpublished reports or manuscripts and personal communications must be footnoted. Include the title, author, pagination of the manuscript or report, and the address where it is on file. For personal communications, list the name, affiliation, and address of the communicator.

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Authors must double-check all literature cited; they alone are responsible for its accuracy.

Figures

All figures should be clearly identified with the author's name and figure number, if used. Figure legends should be brief and a copy may be taped to the back of the figure. Figures may or may not be numbered. Do not write on the back of photographs. Photographs should be black and white, 8- × 10- inches, sharply focused glossies of strong contrast. Potential cover photos are welcome but their return cannot be guaranteed. Magnification listed for photomicrographs must match the figure submitted (a scale bar may be preferred).

Line art should be drawn with black India ink on white paper. Design, symbols, and lettering should be neat, legible, and simple. Avoid freehand lettering and heavy lettering and shading that could fill in when the figure is reduced. Consider column and page sizes when designing figures.

Finally

First-rate, professional papers are neat, accurate, and complete. Authors should proofread the manuscript for typographical errors and double-check its contents and appearance before submission. Mail the manuscript flat, first-class mail, to: Editor, *Marine Fisheries Review*, Scientific Publications Office, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., BIN C15700, Seattle, WA 98115.

The senior author will receive 50 reprints (no cover) of his paper free of charge and 100 free copies are supplied to his organization. Cost estimates for additional reprints can be supplied upon request.

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